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AUTHOR	Bjerstedt, Ake
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ABSTRACT

A three-volume series describes the construction of a self-instructional system as a work process with three main phases: system analysis, system synthesis, and system modification and evaluation. After an introductory discussion of some basic principles of instructional programing, this first volume focuses on the system analysis phase, describing some major sub-phases within the program construction process. The current trends in the choice of areas where instructional programing may be used are identified. A systematic method of determining instructional goals is recommended: first searching for goals with empirical and comprehensive means, then focusing on goals which are behavior oriented and non-conflicting, and, finally, adjusting goals in a series of successive, post-checking revisions. The necessity for an analysis of the special characteristics of the intended student population and the external restrictions on the use of the study material is stressed. Some procedures for examining the logical and psychological structure of the subject matter are presented. The mechanical and non-mechanical devices available to present an instructional system are described and evaluated, including programed texts, closed-circuit television, and teaching machines. See also volume two (EM 009 073) and volume three (EM 009 074). (JY)

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SYSTEM ANALYSIS IN INSTRUCTIONAL PROGRAMMING: THE INITIAL PHASES OF THE PROGRAM CONSTRUCTION PROCESS

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Åke Bjerstedt

The construction of a self-instructional system can be seen as a work process with three main phases: (1) System analysis: Preparatory work (focusing on various "pre-requisites" for the particular instructional situation or on analyses of various components, later to be synthesized into a system); (2) System synthesis: Construction of a preliminary system version; and (3) System modification and evaluation: Post-construction control and improvement. - After an introductory discussion of some basic principles of instructional programming, the present survey focuses upon phase 1 in the program construction process, describing some major sub-phases within the preparatory work.

CONTENTS

PART ONE:
INTRODUCTORY DISCUSSION: BASIC PRINCIPLES OF INSTRUCTIONAL PROGRAMMING

Chapter 1 Introductory Points of View
  Notes on the current situation
  Selection and training of constructors

Chapter 2 Some Notes on Basic Principles
  Some components in an instructional situation
  Some basic principles for self-instructional aids
  Different motivations for the use of self-instructional study-material
  A note on the theoretical model

Chapter 3 The Three Main Phases in the Construction of a Self-Instructional System

PART TWO:
SYSTEM ANALYSIS IN INSTRUCTIONAL PROGRAMMING: THE INITIAL PHASES

Chapter 4 Choice of Area
  Trends
  Some points of view in choosing subject-matter areas

Chapter 5 Goal Analysis
  General aim: Decision on terminal points
  Some possible criteria
  Goal seeking, goal focusing, goal adjustment - some work-phases of a goal-analytic process
  A few queries
  Special aids: Terminal charts, terminal cards, and terminal tests

Chapter 6 Student Analysis and Situation Analysis
  Student analysis
  Situation analysis

Chapter 7 Subject-Matter Analysis
  Examples of procedures for analyzing logical structure of content
  Some reflections on psychological supplementation of the logical analysis

Chapter 8 Choosing Means of Presentation
  Some problems in terminology
  Choosing between mechanical and non-mechanical arrangements
  Various mechanical arrangements
  Amplifying and modifying the observation area
  Various non-mechanical arrangements

1. INTRODUCTORY POINTS OF VIEW

1.1 NOTES ON THE CURRENT SITUATION

Self-instructional study material became during part of the 1960's - not least in the USA - a focal point of educational interest in a manner that few could have imagined only a few years earlier. The large publishing houses fought to be first on the market with new educational programs. Schools, industries and military departments sent their representatives to attend information courses and seminars. Both the educational and the daily press were flooded with informative articles and - equally often - various statements of opinion. Now the situation has partly changed: the hausse of interest is not so marked any more, the commercial claims not so vociferous. This does not mean, however, that there is no interest for the new techniques or that they have been rejected. On the contrary, all over the world work is going on - both in research and in practical product development - using the basic principles of programmed instruction. The experts in the field have increased both in number and in expertise, and - as is so often the case - some of the problems have proved to be more complex that some of the first enthusiasts believed.

The construction of self-instruction material, the so-called "programming", is still somewhat of an art, even though it may also be part of a scientific activity, relying on patient and detailed research. Educational and psychological science has been especially made use of in two respects: on the one hand, as a general source of inspiration, in that many of the basic principles can be said to be generalisations of learning-psychological experiences, established in psychological laboratories; on the other hand, as supplier of a systematic method for assessing the results obtained. The possibilities of basing what lies between - the special technique for converting principles into detailed, concrete study material - on scientifically based knowledge have been far more restricted.

Fortunately, self-instructing material in its hitherto most usual form possesses some few characteristics that encourage us to hope that such moments of uncertainty will gradually - at least to a certain degree - disappear. For it is the self-instructing material more than any other kind of study material that preserves the individual reactions of the student. And it is the champions of so-called programmed education who more than any other group of study-material-constructors have emphasized the importance of constructing the material by means of a series of successive approximations guided by concrete student reactions.

There is reason to suspect that many of the special work techniques now applied are whims of fashion rather than rules based firmly on educational experience. Indeed, we may feel a certain anxiety that such whims of fashion can by reason of their wide scope within the intensive information activity (where persons with little grounding in educational psychology appear, after a short "workshop", as independent programming experts and preachers of the right faith) acquire more the character of definitive and final truth than was intended by their originators.

But on the basis of the above-mentioned qualities - "the continual reaction-recording" as well as the "successive result-adaptation" - the adherents of programmed instruction have built up a self-controlling mechanism. A program-constructor may start from a particularly crazy special idea; if he only follows the principle of successive approximation guided by factual results, he will be compelled to correct himself. It is not impossible that this relatively unique feature in the self-instructing study-material will at the same time facilitate a revival of learning psychology on the basis of data from natural learning situations. We could then perhaps finally pension off the hungry rat and the meaningless syllable as the leading sources of knowledge about human learning.

Even though work during the 1960's has taught us more about how human learning is promoted in self-instructional situations, our knowledge is still rather limited on many issues. In several respects, therefore, a survey of the present kind will be of a preliminary, interim nature. Our hope is that a systematic inventory among other things may serve to give impulses to persons interested in taking part in the continued research and development activities.

1.2 SELECTION AND TRAINING OF CONSTRUCTORS

Who is to carry out the construction work, the drawing up of the auto-instructional study material? Here opinions differ sharply. At one extreme there are those who hold that only qualified, educationally and psychologically trained investigators should perform such construction work. At the other extreme are to be found those who optimistically believe that the students in the elementary school can be allowed to construct their own course material!

The answer depends, of course, to a certain extent on what is understood by the terms "construction" and "programming", respectively. I shall subsequently argue that in such discussions it is important to consider a construction procedure in a broad sense. In a narrow sense, programming involves the composing of a series of tasks and their arrangement in what one believes to be an instructionally appropriate series following certain special principles. In the broad sense programming comprises, in addition to the above, comprehensive preparatory work aimed at, among other things, the examination of goal-setting and subject-matter analysis as well as comprehensive following-up with successive testing and revision of the first version.

Only if the latter, more comprehensive procedure is followed, have the inherent possibilities of instructional rationalization been fully exploited. Should we stop at the first-mentioned procedure, we run the risk of getting caught up in less efficient routines. Unfortunately, many of the programs that are now being marketed do not build on much more than this narrow procedure (since this, from the point of view of the rival publishers, takes the shortest time). This fact is, of course, no reason for anyone to deprive himself of the advantages to be derived from a more adequate working method.

In a complete construction procedure, teamwork would seem to be the best solution in the majority of cases. As a rule it is probably easier to teach a physics- or language-teacher programming than to teach a programmer physics and Russian. The main part of the actual program composition should usually be able to be carried out by a person with good special-subject knowledge as well as teaching experience (an instructor and special-subject expert).

This expert-instructor must, firstly, have taken a course in the principles of programming, and, secondly, have constant access to an educational-psychological expert for consultation. Both the preparatory and the following-up phases involve many tedious tasks that do not have to be carried out by pedagogically qualified staff. As a rule, however, this work should be planned and led by instructional experts with access to special-subject expertise. The result can be a set-up of the following kind:

I. Preparatory work:
Led by expert in instructional technology
Carried out by special-subject expert

II. Composing the basic version:
Carried out by instructor and special-subject expert with special training in programming principles
Supervised by educational-psychological consultant

III. Testing and revision:
Led by educational-psychological expert with statistical schooling
Carried out by instructor and special-subject expert with assistants for writing and calculating work

The most time-consuming work in this model is carried out by the special-subject expert-instructor. The educational-psychological expert - an academically trained psychologist or pedagogue with programming as speciality - devotes comparably less time to detailed work, but on the other hand leads and supervises the project at all stages. As a rule, it is only natural to take the special-subject expert-instructor from the "purchaser institution", i.e. the school type, the firm or the organisations which will eventually make use of the course. The educational-psychological expert can be a consultant from some external organisation, if the organisation in question has not in its own ranks access to a person with these qualifications.

Another conceivable possibility is to take both special-subejct expert-instructor and educational-psychological expertise from outside the purchasing institution for a definite assignment, i.e., to "package-order" a certain course from an institute for programming. In view of the fact that the purchaser gets less insight into the work and less possibility to influence its shaping, and seeing that the school, firm or organisation cannot make use of its learning for further projected courses, this latter "package model" will often turn out to be more expensive for the purchaser. A great deal naturally depends on the personal resources, and hence recommendations that are valid in all situations can scarcely be given.

In selecting persons within the organisation attention should be paid to a variety of factors. Persons should naturally - as has already been stated - be experts in the special-subject sphere, and they should preferably also possess teaching experience (in the special-subject field in question and with students of the kind to which the auto-instructional material is directed).
Certain personal qualities should facilitate this work. Here especially belong analytical ability and ability to express oneself clearly and with simplicity in writing. A good deal of enthusiasm for the task, a large dose of patience mixed with a dash of "perfectionism" should

also facilitate this time- and energy-consuming work. It is often an advantage if two persons work simultaneously in the same course field. They can thus check each others work and by mutual discussion reach the most satisfactory solutions.

The special-subject experts and teachers, who will take part in the construction work, must of course have a certain basic training in the principles and technics of programming. Some experience from such training, perhaps a 2-4 weeks' intensive course, comprising (a) a survey of general principles and of various techniques thus arising, (b) examination of sample good and bad programs, and (c) construction and discussion of one's own practice material, would serve as a good point of departure. Naturally the individual conditions vary, and much of the subsequent work must, in all circumstances, take place under careful supervision and thus at the same time entail further training. It would be advantageous if the survey of principles and techniques could be made with the help of a written manual, to which reference can be made, and which can serve as a recapitulation aid and summary. This is one of the purposes behind the present book.

Efficiency in the subsequent work is of course intimately connected with the educational-psychological expert's skill as study leader and consultant. His learning-psychological and general pedagogic background should be some guarantee that he will not get entangled too easily in stereotyped routines, that he can keep an eye open for alternative solutions and new instructional techniques, and that he is able to look upon individual procedures not only as ingenious contrivances but also as special applications of more general learning principles.

At the same time, however, he must endeavour to follow up what is happening in his rapidly expanding field so that he can become a progressive rather than a status-quo factor in the pedagogic team-work. He should build up a library of the most important general-survey publications and subscribe to some of the international periodicals which publish the latest research reports and current discussions. A few preliminary tips are given in the bibliographic guide given in Appendix II below, the main contents of which the special-subject expert should be acquainted with.

2. SOME NOTES ON BASIC PRINCIPLES

By "self-instructional study-material" we here refer to a study-material that in no way postulates a teacher's continuous engagement in subject-matter organization, the detailed presentation of subject-matter or examinations, and that in its arrangement endeavours to follow certain principles (partly based on communication theory and the psychology of learning) in order both to make such self-instruction possible and generally to promote the effectiveness and efficiency of the instruction.

In the present section we shall briefly present some general background arguments together with some notes on the basic principles which have hitherto often been followed in the construction of self-instructional materials. Some of these principles are of a very general character, others are more specific. Some are relatively generally accepted, while on others opinions are more divided. Continued work with self-instructional materials will probably in due course provide us with a better knowledge of the durability and general validity of the various background principles. Some of these background principles will probably have to be modified or given a more specific shape.

2.1 SOME COMPONENTS IN AN INSTRUCTIONAL SITUATION

It may be appropriate to start the discussion by trying to outline some main components of a typical instructional situation. First, it may perhaps be tempting to give the outline the following simple form:

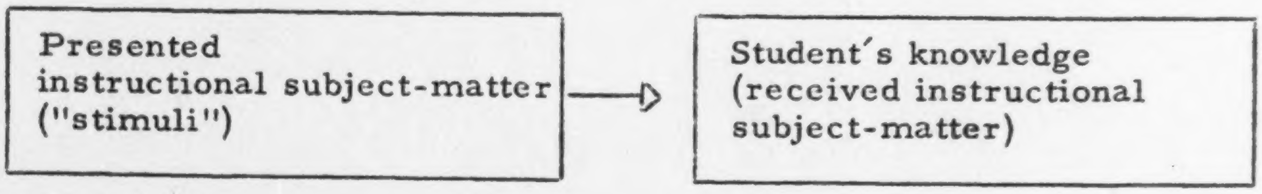

Figure 2.1

But the student, of course, is not a container which can thus easily be filled with knowledge. We understand that the outline gives a far too simplified picture of the knowledge-imparting process, seeing that it does not take into consideration the fact that the ability of different persons to "receive" material varies - owing to, among other things, dissimilarities in previous experience and a fluctuating degree of attention at the specific moment of instruction. Thus, we could schematically imagine the individual student as a receiver with, for various reasons, a reduced receiver-capacity at the moment of instruction or as a "knowledge-filter" that only retains part of the instructional material presented:

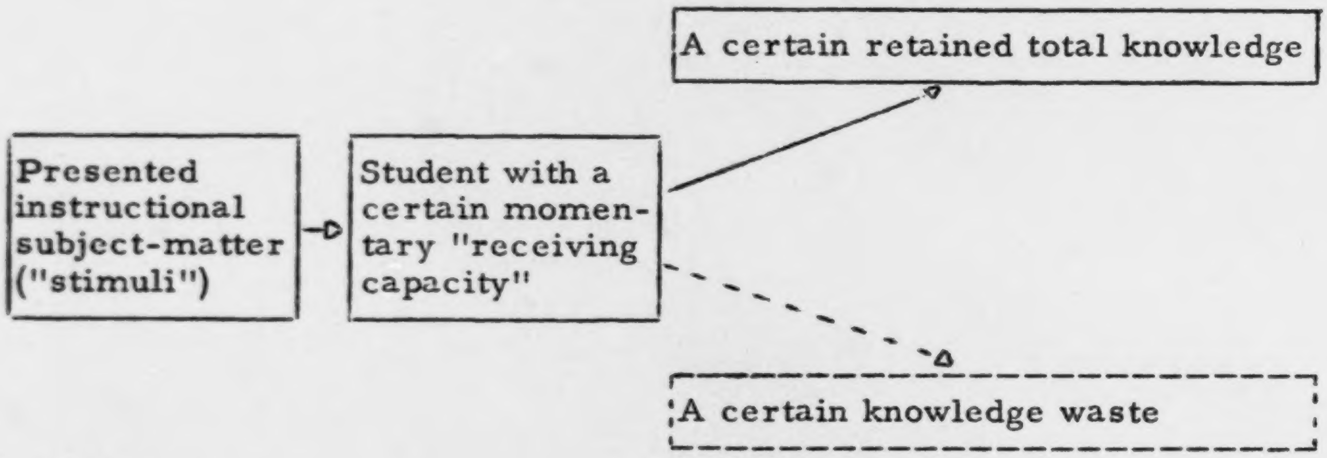
A certain retained total knowledge
Presented instructional subject-matter ("stimuli")
Student with a certain momentary "receiving capacity"
A certain knowledge waste

Figure 2.2

Our outline, however, still only includes some very crude main components in the instructional situation. The external stimulus situation contains some other elements in addition to the specific subject-matter to be learnt. Some of these facilitate the learning (as remedial information, certain instructions for behavior and stimulating evaluations), other elements are relatively neutral for learning (a number of environmental elements), whereas others again render learning difficult (disturbing environmental elements such as noise or interest-diverting "distractors"). The "external stimuli" can thus be divided up into intended information material (or "focal" stimuli) and stimuli of other kinds.

Similarly, the student's "receptive capacity" is a complex phenomenon: it depends partly on special experiences and expectations in the now-situation, partly also on certain more general reaction tendencies, deriving from earlier experiences.

Finally, we must pay attention to the fact that what is really learnt in the instructional situation is often not only specific information (knowledge of specific subject-matter), but also more general action- and experience-tendencies (study techniques, attitude to the special-subject field and so forth).

These discussions lead, in other words, to a further re-arrengement of our figure:

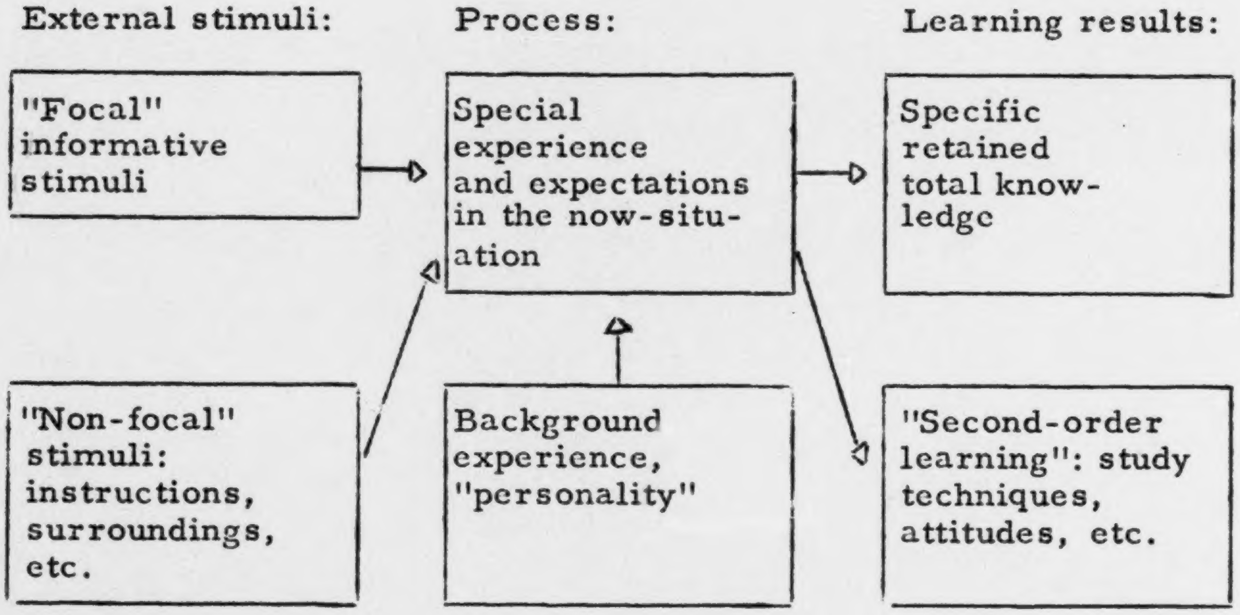
External stimuli:
Process:
Learning results:
"Focal" informative stimuli
Special experience and expectations in the now-situation
Specific retained total knowledge
"Non-focal" stimuli: instructions, surroundings, etc.
Background experience, "personality"
"Second-order learning": study techniques, attitudes, etc.

Figure 2.3

In order to be able to carry out a closer analysis of the effectiveness and efficiency in such a "communication system", we should, however, make at least a few more sub-divisions so that certain important elements should not be forgotten. We will then arrive at an outline of roughly the appearance seen in Figure 2.4. At first sight this outline perhaps looks terrifyingly complicated. A comparison with Figure 2.3 and a study of our subsequent commentaries should, however, make it easier to understand.

Let us first examine the "stimulus" end. By this we mean the external incitement or influences of various kinds that affect the student in the instruction situation. Here, of course, the "focal informative stimuli" are of cardinal importance: these are the elements, the very information units that we wish our students to acquire. They constitute the focus of the instructional situation, whether they be presented in the shape of tasks in the teacher's oral presentation, of data in a book, or of information provided by a tape-recorder or a film.

Besides these "focal stimuli" we usually have others, which are essential for learning: accompanying information (not intended to be learnt, but rather to elucidate further or to facilitate the learning of the focal subject-matter), supporting evaluations and instructions closely related to the subject-matter (furnishing the student with directions as to how he should behave in a certain instructional situation or as regards certain parts of the presented subject-matter). We can call these stimuli "correlative" in order to make clear that they stand

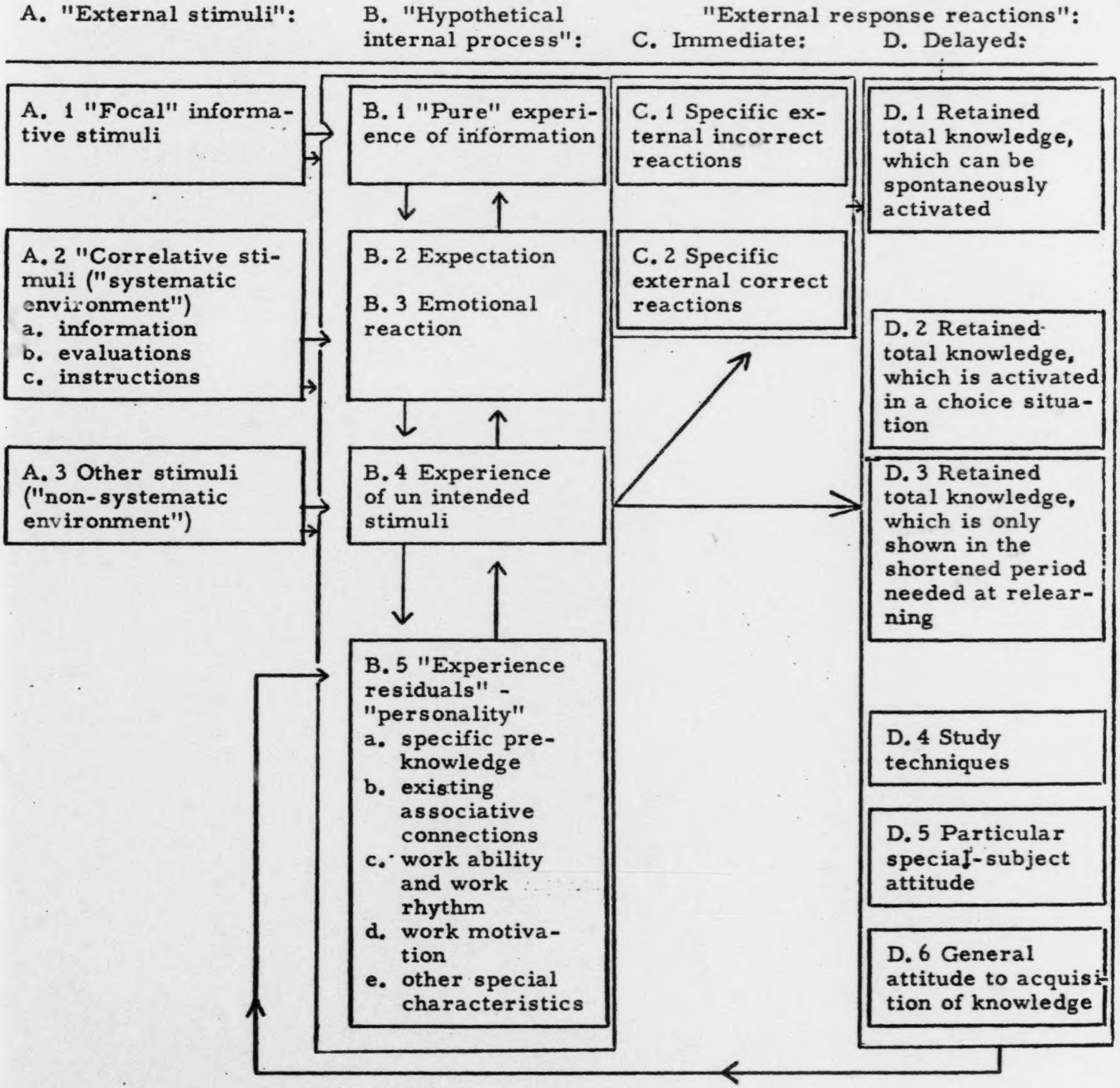
A. "External stimuli":
B. "Hypothetical internal process":
"External response reactions":
C. Immediate:
D. Delayed:
A. 1 "Focal" informative stimuli
A. 2 "Correlative stimuli ("systematic environment")
a. information
b. evaluations
c. instructions
A. 3 Other stimuli ("non-systematic environment")
B. 1 "Pure" experience of information
B. 2 Expectation
B. 3 Emotional reaction
B. 4 Experience of un intended stimuli
B. 5 "Experience residuals" - "personality"
a. specific preknowledge
b. existing associative connections
c. work ability and work rhythm
d. work motivation
e. other special characteristics
C. 1 Specific external incorrect reactions
C. 2 Specific external correct reactions
D. 1 Retained total knowledge, which can be spontaneously activated
D. 2 Retained total knowledge, which is activated in a choice situation
D. 3 Retained total knowledge, which is only shown in the shortened period needed at relearning
D. 4 Study techniques
D. 5 Particular special-subject attitude
D. 6 General attitude to acquisition of knowledge

Figure 2.4 An hypothetical sketch of an instructional situation. (For more detailed explanation of outline, see text.)

in a certain systematic ("accompanying") relationship to the actual core of the subject-matter. On similar grounds we might speak of them as "systematic environment". The remaining stimuli in the situation then form the inevitable "non-systematic environment", comprising all other factors in the immediate surroundings (possibly persons present, miscellaneous objects in the vicinity and such circumstances as light, humidity, temperature, traffic noise etc.).

Let us for the present skip the hypothetical "inner processes" and instead look at the observable external reactions. What we directly get an idea of is the immediate response reactions: correct and incorrect actions in the instruction situation. What we are most interested in, however, is of course not these short-term effects but instead the "delayed" reactions: the long-term effects or such student reactions as indicate a certain residue of knowledge in an application situation on a later occasion.

In the outline we have given three different ways in which such "retained total knowledge" might show itself concretely, namely, (a) correct behavior in a situation with a minimum of external guidance, (b) correct behavior in a well-defined choice situation (where the main task is to choose the correct alternative from a series of given choice possibilities), and (c) ability for quicker relearning of subject-matter which cannot be spontaneously activated. The first case entails the highest degree of residual knowledge, the last case the lowest.

What we previously called "second-order learning" has here been sub-divided into three categories: teaching effects regarding (a) the student's study techniques (the student may have acquired a good study technique, even if he cannot himself activate the special-subject material itself), (b) his attitude to the special subject in which he has been instructed (he has perhaps a good residue of subject-matter but has acquired such a negative attitude to the subject that he will never voluntarily take an interest in it hereafter), and (c) his general attitude to the acquiring of knowledge on the whole (ranging from the view that study is a privileged pleasure to that of study being something only to be done under direct coercion).

The intermediate links between external stimuli and final reaction - the hypothetical inner processes - cannot be observed by us in the same direct manner. But we can study different persons' descriptions of how they experience these processes, and, indirectly, we can draw certain conclusions about them on the basis of experiments and correlative investigations.

We can imagine that the experience in the now-situation comprises: partly, a relatively "pure" experience of both focal and non-focal stimuli (i. e., an experience minimally influenced by factors other than the stimuli themselves); partly, a series of expectations (created by, among other things, such - previous - experiences) as to what shall further be presented or as to certain connections between different informational units; partly, also an emotional experience of the subject-matter and other parts of the learning situation.

Usually, we can only separate these elements in theory. In most situations the interplay between them is in all probability very close. It can, for instance, be extremely difficult to differentiate between expected experience and "pure" experience, something that occasionally is expressed in "incorrect perceptions" on the basis of keen (but unjustified) expectation. Often, in this connection, expectation has both a selective and a reshaping (simplifying, sharpening) function.

Experience in the now-situation is, in addition, influenced by the student's general experience-background and the more permanent characteristics of his personality, e.g., by the student's specific pre-knowledge, general ability, motivation and other special characteristics. Certain persons can, for instance, by their personal disposition be more inclined, quite unthinkingly, to attach more importance to the element of expectation than to the recording of unexpected external experiences, whereas others - just as unthinkingly - are more disposed in the first place to pay attention to the realities of the external situation.

The construction of self-instructional study-material starts from the general aim of creating an effective learning situation. By "effective" we generally mean a situation in which, starting from the goal definitions, an optimal combination of behavioral products (column D in Figure 2.4) is obtained in a minimal period. In shorter courses with well-defined proficiency content this usually indicates - to use a somewhat different formulation - a learning situation in which the greatest possible quantity of the "focally informative stimuli" is retained as easily activated total knowledge in the student as the result of a process entailing a minimum of time-consumption and a minimum of non-desirable side-effects (for instance, negative attitudes).

In order to be able to make an assessment of a certain situation's effectivity we must necessarily (a) clearly state in advance the scope and content of the desired total knowledge with a specification of the actualisation type (e.g., alternative D.1 or D.2 in Figure 2.4) and (b) decide upon certain tolerance limits for time-consumption and negative side-effects. In certain cases, for instance, the question of time is of subordinate interest, and the demand is for a complete mastery of a certain behavioral repertoire. So, for instance, the driving-licence candidate must train until he reaches a certain acceptable level of performance, regardless of how long this takes him. In other cases we only have a limited amount of time, and it is a question of fitting within this time-frame as great a total knowledge as possible within the given field. This is often the case within the framework of the compulsory school. Again, in other cases, it is a question of finding the optimal balance between time-consumption and acquired subject-matter so that the learning procedure is broken off at a point in time when further proficiency learning would entailusing - according to certain criteria - a disproportionately large period of time.

When assessing learning effectivity it is of course (as pointed out in our general definition of effectivity) important to pay attention to all links in the teaching product (cf. column D in Figure 2.4) and decide in advance which sub-part (or sub-parts) is the most essential in the event of their coming into conflict with one another or being to different high degrees encouraged by different instructional procedures. Instructional rationalization must not of course trample on the acquired work techniques or study-attitudes, in the cases where these aspects are essential to the goals defined for the specific teaching area.

In this respect there is very often a certain difference between shorter training courses for a certain specific post and the more generally oriented training, which, for instance, takes place in the compulsory school. In the former case the goals are comparatively specific and the total knowledge in consequence relatively well-defined or at least in principle easy to define. In this case the instructional rationalization can move ahead rather strictly, cutting away irrelevancies and focusing upon the specific proficiency goals. In other cases - as in the compulsory school - the goal area is considerably broader: many would agree that for several subjects the work techniques and the general attitude to learning are often more important than the particular factual subject-matter, which can easily be activated by the student at a certain time. In such a case, the effectivity definition should also clearly state this in terms of goal priorities so that one does not in ignorant and one-sided rationalizing zeal rationalize away just that which one most wanted to gain. An effectivity assessment without a goal analysis is in all circumstances impossible.

2.2 SOME BASIC PRINCIPLES FOR SELF-INSTRUCTIONAL AIDS

Let us in a few points briefly state the means by which, when constructing self-instructional study material today, we endeavour to increase effectivity in communication and teaching.

1) By a detailed goal analysis we attempt to clear away irrelevancies so that we can clearly concentrate on the "focal" informative stimuli ("total focusing") essential to the objectives.

2) By a penetrating analysis of the structure of the subject-matter we facilitate a break-down of the subject-matter into appropriate presentational units, which still further contributes to the focusing, the directing of attention on the central information ("itemized focusing").

3) The analysis of the structure of the subject-matter also makes possible better planning and more adequate decisions on sequences which facilitates the teaching. In making a sequential decision we pay attention to, for instance, such general principles as that more complex proficiencies are built up on the basis of more elementary ones; also, systematic repetition is built into the study material itself (and therefore not entirely handed over to the student's own initiative or lack of same).

4) By a systematic use of "correlative stimuli" in the earlier stages of the learning process we make certain that the correct "expectation" is created in the student so that he swiftly succeeds in finding the correct solution. This generates an early training of correct behavior (instead of early incorrect behavior with subsequent risk for a more time-consuming training process). Usually it also generates an emotionally positive experience of having succeeded, which in many cases acts in an allround stimulating and "motivation-increasing" manner.

5) By a successive "fading" of these accompanying support-stimuli during the progressive learning process we make certain that the student learns to fulfil his task "on his own" (without having to suffer too

many defeats on the way to this goal).

6) By the above-mentioned steps, which all have to do with the "stimulus", we do everything possible to prevent irrelevant stimuli from being woven into the course material. By special arrangements - machine presentation or special types of book presentation - we often also endeavour to prevent the student from taking such liberties with the material that the projected planning is destroyed.

7) By careful advance-analysis of the course material's normal public - the so-called "target population" - we try to get to know the students; for instance, their common pre-knowledge, reading ability and special characteristics, so that effectivity in communication becomes optimal (tasks neither too difficult nor too easy).

8) Knowing that learning becomes more effective when the speed with which the information is imparted can be adapted to the individual, we arrange the learning situation in such a way that the student is allowed to work at his own tempo. Thus we prevent both the slow student losing important information, and the quick one being bored to death. The not uncommon average-centered or somewhat-below-average-paced instruction is thereby replaced by a more individual-centered technique.

9) In cases where this speed-individualization does not seem sufficient to neutralize the inequalities in the students' experience-backgrounds and personalities, we build some branching technique into the program. This entails in principle that certain students (on the basis of their performances or attitudes when at work) are streamed along special routes through the study material. This, for instance, can mean that a student with a higher level of pre-proficiency can take a "shorter route", that a student with a lower level can take a "longer route" with more repetition, or that a student who lacks certain special pre-knowledge gets a little built-in "remedial course" to repair the deficiency in question. Branching can also be shaped in such a way that students with different views or attitudes can study different exemplification materials or be confronted with varied types of argumentation in order to attain by different, individually adapted routes the same conclusions in principle. Finally, we can in certain cases arrange the material in such a way that the student on certain points may himself choose whether he will have a question further clarified by going through a "higher course section" ("voluntary branching").

10) Since learning is more effective when the "flow of information" is always met by active attention, the teaching situation is usually shaped in such a way as to exploit the "student-steered stream of information". The information does not then continue to flow (as, for instance, is the case during a lecture or at a conventional lesson in a class), if the student relaxes his attention, "goes to sleep" or must go to the dentist. When he concentrates again, "wakes up" or returns from the dentist, ha can, in other words, continue where he left off and has therefore not missed any important links in the thought-chain.

11) In order further to ensure that his attention shall not slacken, we usually arrange the study material in such a way that the student is compelled to give "external response-reactions" at short intervals and in immediate association with the individual presentation-units. To read pen in hand has been an old study-technical tip. In programmed study material the activity principle is built into the system.

12) With the aid of a "successive feedback technique" the student is most often immediately allowed to know whether his response reaction is correct or incorrect. In addition to its attention-promoting effect this procedure has certain other advantages. If the student has acted correctly (which is usually the case due to the carefully planned step-by-step presentation-manner), he not infrequently receives an unambiguous progress-experience which increases his pleasure in working. If, on the other hand, he has acted wrongly, he is at once corrected, and the likelihood of the wrong response tendency being retained is therefore lessened.

13) If the incorrect responses are of some fundamental importance ("systematic" errors), and if sufficient correction does not automatically occur in the following work sequence, special remedial instruction can be built in. (Remedial instruction of this kind is in its quality of both "micro-branching" and "extended feedback" more or less a special case of both points 9 and 12.)

14) At the end of the study material or after certain part-sections of the study material we usually build in test-tasks giving a preliminary idea of the retained total knowledge and the acquired work-technique, and which at the same time demonstrate to the student what he has learnt.

15) The student's immediate external response reactions in the course of the instructional process have significance not only as activi-

ty-promoting devices, but also as permanent reaction data for later successive analyses. Thus they can be used for diagnostic information about the student's continued need of supporting material or his ability to benefit from more advanced study material. But they can also be used as a basis for further effectivisation of the presentation-units or the reshaping of the presentation-sequence. The latter mode of use is in itself a central point in the construction of self-instructional study-material. The student's reactions (both the immediate ones during work as well as the delayed ones, which give us information as to the retained total knowledge) are the final indicators of the study-material's effectivity. Continuous testing and revision under the guidance of the student's reactions constitute therefore a normal phase in the work of construction.

The above fifteen points can be said to summarize some of the main characteristics distinguishing an effective self-instructional study material. Several of these characteristics also describe an effective instructional situation in general. It is obvious, for instance, that a detailed goal analysis and a revision of the presentation-forms on the basis of the student's reactions also constitute important factors which promote effectivity in the usual classroom instruction. Hitherto it has been the champions of self-instructional study material who have most strongly stressed the value of applying procedures of the kind outlined here. The reason - among others - is that the demands on the self-instructional material's clarity, unambiguity and effectivity must always be placed on a high level, seeing that the possibility of more improvised improvements and clarifications when required, as offered by conventional classroom instruction, does not exist in the self-instructional situation.

The above fifteen points should be examined by the reader both in relation to the hypothetical outline of an instructional situation as given above (Figure 2.4) and as a background to the following concrete survey of different stages in the construction work. The first six points deal mainly with "the stimulus side" (column A in the figure); points 7 - 9 touch on the adaptation to the inner process, especially the student's varying background-experience (column B); points 10 - 15 mainly refer to "the reaction side" (columns C and D in the figure). Of course, much of what has been said above - for him who is not, in advance, at home with the special nature of the self-instructional aids

- may appear slightly abstract. We hope, however, that the more detailed presentation below will make our points of view much more concrete and clear.

2.3 DIFFERENT MOTIVATIONS FOR THE USE OF SELF-INSTRUCTIONAL STUDY-MATERIAL

We can choose self-instructional study-material for different reasons. Some common motives are the following: (a) An insufficient number of teachers at several places where instruction in a certain subject-matter is needed. (b) The habit of working on one's own with self-instructional study-material is considered important for the student's study technique and training in independent work. (c) The possibility of differentiating work-pace is considered essential in heterogeneous classes with sharply varying background conditions for the students. (d) The self-instructional study material is considered a more rational and effective instrument, which leads more quickly to intended results.

All points of departure are of course valid in different connections, but the reasons must be explicitly clarified, as different motives can and should lead to certain shifts in the centre of gravity in construction work.

Thus, the fourth of the above-mentioned points of departure, d, places the greatest emphasis on rationalization and effectivity. In this case the clearing away of irrelevant stimuli and the study of time-consumption and retained total knowledge are particularly essential. Here comparative investigations of effectivity in different forms of instruction are of obvious interest. Seeing that efficiency is of focal importance, the self-instructional technique should not as a rule be applied in cases other than those which are really proved to lead more quickly to the goal than alternative instructional forms. These lines of thought often apply to shorter adult courses intended for special, well-defined training goals.

The first-named point of departure, a, however, gives a case in which alternative instructional possibilities need scarcely be considered. It would be rather a question of arranging a kind of "rationalized correspondence instruction". Efficiency comparisons with lesson instruction are hardly relevant in this connection.

Motivations b and c would probably be often of importance in the compulsory school. Then it is important that we do not at the same time blindly stare at a one-sided interpretation of the effectivity demand in terms of subject-matter knowledge learnt. Comparisons between the efficiency and effectivity of different work forms is of course always of interest, but knowledge effectivity is not the only decisive factor. A lower knowledge-effectivity linked with better work-habits or with greater enjoyment of work and pleasanter disciplinary conditions would certainly be considered a fully acceptable goal by many teachers. Here as elsewhere we must not hesitate to declare what we consider to be the most essential - and then keep to the priorities. But naturally we must then not forget to see to it that the new, not merely knowledge-oriented goal is also realized. In other words: we must not relax our efforts in the conviction that self-instructional study-material may be useful for study techniques and work training, but we must of course actively strive to get the material so shaped that there will be favorable conditions for this target to be attained - and subsequently we must also try to check the result. Certain forms of self-instructional material can, for instance, be thought to accustom the students to a far too chopped-up and stereotyped spoon-feeding or to guessing their way to their responses rather than thinking them out. A priori is not work with all types of self-instructional material of value for independent work training.

2.4 A PARENTHETICAL NOTE ON THE THEORETICAL MODEL

It has perhaps struck some readers with a knowledge of current works on the subject that the above background discussion has not contained a single word about animal-psychological studies. Nor have we spoken of "reward" or "reinforcement" techniques or of the successive shaping of existing behaviors - terms and expressions that surely play a central part in the discussion about the learning-psychological background. For Skinner - outstanding animal psychologist and one of the leading exponents of self-instructional study-material - it was only natural to formulate the theoretic model in what psychologists are wont to call strictly S-R-theoretic terms and together with animal-psychological illustrations.

In a historical survey this type of argumentation has its place. I have also to some extent followed a procedure of this kind in another context. But at the same time I think it may be a disadvantage to bind oneself one-sidedly so that one always describes and thinks in these categories. The disadvantages are of two kinds: the one external (communication-psychological) and the other internal.

The external disadvantage is that the animal-psychological illustrations and terms have a tendency among certain listeners to rouse an unnecessarily negative attitude in advance which not infrequently blocks a continued exchange of thought. The rat-psychological perspective thus often becomes an unnecessary communication barrier. If the same basic principles can be demonstrated in experience-material that lies closer to hand, then there is a lot to be said for letting the rat remain in his cage.

The other disadvantage is of a more fundamental nature. I believe - and on this point perhaps many hold another view - that it would be unfortunate for the future development of self-instructional study-material to bind oneself to a strict S-R-theoretical model. This point of departure has already in a few cases led to surprising formulations of experience data and a certain disposition to overlook important realities. Different behavioral theories ought probably to be first seen as different ways of classifying and describing a variegated reality. There is nothing, in my view, that says that experiences and results from studies of self-instructional study material cannot be described just as well in other terms as in those that are typically Skinnerian.

Here I have chosen to start from a simple communication-psychological model including cognitive and personality-psychological elements. In any case, I myself feel such a point of departure to be more flexible and more natural in describing what happens in a human learning-situation, and it seems to me to give greater scope for broad explorations fruitful for the further development of the method. It would also seem to facilitate comparisons between these special instructional forms and other types of human instructional situations. Obviously neither the one nor the other model type should be taken too seriously. Models are convenient data-summarizers and useful sources of inspiration - but they are of course never more important than the basis of empirical facts on which they build, and about which some sort of agreement is usually relatively easily attained.

3. THE THREE MAIN PHASES IN THE CONSTRUCTION OF A SELF-INSTRUCTIONAL SYSTEM

The construction of self-instructional material can, of course, be approached from many different angles - some of which can be described more precisely than others. Concerning the details there is still considerable disagreement among different schools. On the other hand, relatively good agreement has been reached in principle with regard to the broad lines, the main phases of the work. The fact that, for reasons of time or economy, the complete procedure has not always been fully exploited in the concrete tasks, is a different matter.

The presentation which follows is based on a view of the construction process which distinguishes three main phases of the work:

1. System analysis: Preparatory work
2. System synthesis: Constructing the preliminary version
3. System modification and evaluation: Testing and revision.

The preparatory work comprises all the important work which must be done before the constructor can sit down with a clear conscience and formulate presentational units intended for direct student work. It includes a detailed analysis of the special goals of the instruction, of its external conditions in the actual situation and of the special characteristics of the relevant subject-matter. Certain preliminary decisions as to presentational media must also be taken at this early stage. In general, the preparatory work focuses upon an "analysis" of the components to be put together later in the "synthetic" phase.

On the basis of the results and decisions of the preparatory analysis, the material-constructor then begins the construction of a preliminary version, in which he must also pay attention both to principles for the shaping of the individual presentational units as well as to guiding-lines for their mutual arrangement.

The quality of the preliminary version varies of course considerably depending on the subject-matter's character, the thoroughness of the preparatory work and the constructor's background experience and general aptitude for the work. The third main phase comprises a gradual testing of the preliminary version with successive revisions and a terminal field-test on representative groups, designed to yield guidance and information to the potential user: a kind of "informative label".

Certain assessments of the scope of the different main phases (calculated in working-hours consumed and/or costs) are to be found in the literature. Deutsch (1962, p. 211), for instance, calculates that appro 25 % of the total investment of time and money is disbursed in preparatory analyses, approx. 30 % in the constructing of the first version, and approx. 45 % in successive tests and revisions. Naturally such statistical information cannot be generalized, since the special conditions of work in each individual case will create a partly unique situation. The scope of the preparatory work varies, for instance, to an extraordinarily high degree depending on whether any kind of preparatory analysis already exists in the shape of detailed course planning or whether the constructors are compelled to begin from rock bottom (starting only from a general and vague formulation of the instructor's goals).

Nevertheless, it can be of a certain interest to note the above-mentioned figures. The beginner in the field sometimes has a feeling that the main part of the work consists of a direct construction of study-material according to a series of rules of thumb, and that what is here called preparatory work and testing together with revision, respectively, constitutes side activities demanding comparatively little time and work. In reality, however, Deutsch estimates that less than a third of the total investment is disbursed on such direct construction. (For a more detailed discussion of the economical aspects of work and time, see, e.g., Klaus & Lumsdaine, 1962; Kopstein & Cave, 1962.)

As is already obvious from the description of the different main phases above, several sub-phases have to be dealt with -- for instance, in the following manner:

1. System analysis: Preparatory work
    1. 1 Analysis of prerequisites
        1. 1. 1 Choice of subject-matter area
        1. 1. 2 Goal analysis: Decision on terminal points
        1. 1. 3 Student analysis: Clarification of initial points
        1. 1. 4 Situation analysis
    1. 2 Subject-matter analysis
    1. 3 Preliminary decisions on media-method combinations

2. System synthesis: Construction of preliminary version
    2. 1 Preparatory decisions on sequences and procedures
    2. 2 Working out instructional sub-units, deciding on
        2. 2. 1 Information elements
        2. 2. 2 Response requests
        2. 2. 3 Result indications
    2. 3 Final adjustment of sequences and media

3. System modification and evaluation: Post-construction quality control and improvement
    - 3. 1 Systematic pre-testing examination
    - 3. 2 Successive testing and revision
    - 3. 3 Final field testing
    - 3. 4 Writing of manual

In the following survey we shall broadly follow the work plan outlined here.

4. CHOICE OF AREA

When an organization or a school begins to consider converting certain courses into a self-instructional form, several questions of choice arise at the very start. Which fields are the most suitable? In which area should we begin? Are there any fields that we should not include?

4. 1 TRENDS

An examination of the distribution of published courses for various subject-matter areas may be of some interest in this connection. For instance, reference may be made to the early lists of programmed courses on the U. S. market, drawn up by the Center for Programmed Instruction, New York, or similar lists on programs available on the market in Britain, compiled for the Association for Programmed Learning and Educational Technology, London.

Table 4. 1 shows that the distribution of subjects in U. S. programs for the three years given is fairly similar despite the differences in the number of courses avialable. It is easy to see a tendency towards a

Table 4. 1 Survey of the distribution of subjects in American programmed courses (according to the information available for 1962, 1963, and 1965)

Subject	1962		1963		1965	
	No.	%	No.	%	No.	%
Mathematics	52	43	123	35	49	16
Science	24	20	69	20	70	24
English	16	13	51	14	56	19
Foreign languages	10	8	21	6	9	3
Social studies	7	6	16	5	22	8
Business education, economics	4	3	22	6	17	6
Programming	2	1,5	9	3	3	1
Miscellaneous	2	1,5	41	11	65	21
Total	117		352		291	

The figures give a content survey of programs available for purchase in Sept. 1962, Sept. 1963, and April 1965. The data have been obtained from the publishers by the Center for Programmed Instruction at the request of the Office of Education (cf. "Programs,´62" "Programs, ´63", and "Programed instruction materials 1964-´65").

Table 4.2 Survey of the distribution of subjects in programs available on the market in Britain in 1969 (according to subject classification in Cavanagh & Jones, 1969)

A. Subject headings with more than 50 titles

Biological sciences	99
Chemistry	82
Civic affairs	62
Commercial subjects	91
Computers	53
Earth sciences	78
Electricity and electronics	106
Engineering	199
English	130
Industry	51
Management and supervision	67
Mathematics	572
Physics	88
Reading	57

B. Subject headings with 10-50 titles

Foreign languages, General subjects, Health education, History, Medicine, Nursing, Programmed instruction, Slide rule, Statistics

C. Subject headings with less than 10 titles

Bridge, Carpentry, Dentistry, General science, Librarianship, Linguistics, Logic, Music, Photography, Physical education, Religious education

Total number of programs classified 2004

Note: The editors have tried to list all teaching programs - both industrial and educational - available on the British market in 1969. Of the about 2000 titles, most are of British origin (about 1600 programs); the rest are mainly American programs. In this survey, mathematics programs form the largest single subject category, with 572 titles (or 29 % of the total). The second largest category is engineering with 199 programs (10 %), and the third is English with 130 entries (6 %). - Figures in Tables 4.1 and 4.2 are not directly comparable, since principles of program selections and classification are somewhat different.

preponderance of some special subject-matter areas, especially mathematics and science. It is worth noticing, however, that the relative proportion of mathematics decreased from 1962 to 1965. Table 4.2 gives a survey of programs available in Britain in 1969. In spite of a considerable breadth of topics used, mathematics and the natural sciences still form particularly large sub-categories.

Surveys of this kind must not be overrated. What was applicable during an early period need not necessarily be applicable later on in a field developing rapidly. But a statistical survey of this kind gives us some idea of what publishers and course programmers have, up to a certain point of time, regarded as the easiest material to convert into self-instructional courses. From this, it need not follow, of course, that other fields are unsuitable for programming. The conspicuous increase in the number of programs under the heading "Miscellaneous" in Table 4. 1 indicates that the range widened rapidly to include new fields. A quick sample of subject indicators in the index of the 1969 British list of programs in print testifies further to the diversity: Accident prevention, Battle of Hastings, Choosing a job, Decision making, Electrocardiography, Frost precautions, Growing adult, Hypnotism, Insurance policy, Julius Caesar. Keybord mastery, Latin, Melodic perception, Neurosis, Ohm's law, Poetry, Queen and parliament, Roentgenology, Smoking, Traffic signs, United Nations, Volcanic activity, and Weft knitting.

4. 2 SOME POINTS OF VIEW IN CHOOSING SUBJECT-MATTER AREAS

Some points of view that may be taken into account in choosing subject-matter areas are listed below.

"Subject-matter points of view"

(a) Subject-matter which has a relatively easily distinguishable logical structure would seem to lend itself more easily to the usual types of self-instructional material than other kinds. It is probably this, among other things, that is reflected in the large number of courses in mathematical subjects, especially during the early period. One might also say that mathematics is one of the subjects in which older teaching approaches have certain similarities with the technique of programming (an alternation of new information, solving problems, result indication). In other words, the step from conventional to programmed techniques may be said to be shorter in mathematics than in some other subjects. The advantages of using subject-matter that has an easily distinguishable logical structure are firstly, that structural analysis and sequential arrangement are easier, and secondly, that there is no great difficulty in deciding what should be considered "focal" stimuli and irrelevant stimuli respectively.

(b) On the other hand, the not uncommon view that routine material with emphasis on pure drilling (unrelated facts: names, symbols) is particularly suitable for the current forms of programming, is based, partly at least, on a misunderstanding. Such material can of course be practised by the student himself, perhaps with the aid of a machine, but as a rule the effectiveness of the learning process cannot be increased by the form of systematic constructional work usually associated with the term "programming". The reasons for this are obvious: material that is not structured in itself does not gain anything by structural analysis, and material to be learnt by heart in its entirety and as unrelated items cannot usually be made more meaningful by focusing and weeding out irrelevant stimuli - all stimuli are equally focal! (For experiments connected with this argument, see Shettel & Lindley, 1961; Hughes, 1962, p. 58.)

(c) One factor that should be taken into account, on the other hand, is the degree of permanence of the subject-matter. It should be borne in mind that conversion to effective self-instructional material requires so much labor that it is important not to expend this labor on a field in which today's problems are out of date tomorrow.

(d) A more tactical point of view concerning subject-matter is that the beginner should not try to embrace connected work units that are too large. It is important for him to arrive at a preliminary test relatively quickly. If the first attempt does not turn out well, not so much time has been wasted, and the constructor of the course can start revision work with equanimity and little loss of prestige.

"Student points of view"

(e) A not unimportant consideration in the choice of area is the estimated number of students who are going to use the material. If there is only a very small number, the amount of work required for the programming may perhaps be considered out of all proportion to the returns. (Cf. Kopstein & Cave, 1962.)

(f) If experience shows that sections of a course present the students with particular difficulties when conventional teaching methods are used, or when other types of course material available are totally inadequate or do not exist, then these sections would be natural starting areas for programming attempts, providing other circumstances are not clearly contra-indicative.

(g) When it is difficult or expensive to bring together potential students scattered over a wide area for a centrally organized course under the direction of a number of experts, there is good reason to investigate the possibility of arranging tuition using self-instructional material on the local level thus avoiding travelling expenses, the costs of living away from home, etc.).

"Instructors' and constructors' points of view"

(h) Subject-matter for courses for which it is difficult to find a sufficient number of qualified teachers naturally suggests itself for programming. For this very reason considerable interest in programmed courses has been shown in countries in which the school system is undeveloped.

(i) Subject-matter for courses for which it is difficult to find experts in a particular subject to act as constructors should, however, be left alone until experts can be found. Considering the total costs of the work on a course, amateurism in the subject-matter area should never be tolerated.

It may be thought that most of the above points are rather obvious. Since labor and resources are very much tied down by large-scale constructional projects of this type, the initial choice of subject-matter areas is by no means unimportant, however. Nor is it particularly unusual for constructional work to be started without careful consideration of the factors mentioned here - motivated only by a causal interest. In order to prevent inadequately planned instructional projects of this kind giving poor initial results, there is every reason to consider these apparently commonplace arguments with a good deal of care.

5. GOAL ANALYSIS

5. 1 GENERAL AIM: DECISION ON TERMINAL POINTS

Once a particular area has been selected, the next task is to analyze the teaching objectives. Analyzing the objectives is, or should be, a vital stage in planning all instruction. The obligation to make such an analysis, however, is usually felt to be much stronger in constructing self-instructional material than in other contexts, particularly because of the importance generally attached to precision in supplying information, well-planned sequences and clearly registrable effectiveness (and of course, because of the absence of a teacher as a "correction factor"). The "pedagogic conserves" - collections of facts that have been made more or less by chance and that have been retained because of routine or tradition rather than necessity - are numerous in most teaching areas and if goal analysis can break down the fences round some of these "conserves", it will be doing some good, quite apart from the results bearing directly on specific self-instructional materials.

The use of systematic goal analyses in the field of education is no novelty. Nevertheless, goal-analytic arguments are undoubtedly accorded greater importance in educational discussions and planning today than they were earlier. It is not unknown these days for a student to ask his academic teacher what the aim of the course being taught is; such stimulating direct questions were certainly not common before. But the fact that publishers, textbook writers, teacher trainers, education planners, etc. , speak more and more of objectives and goal analysis does not mean that they particularly agree about what these terms imply.

The terms obviously crop up in discussions with more persistence than accuracy. Those using them have sometimes proved to be comparatively unaware of how a systematic goal analysis functions and, when given descriptions of typical procedures, they often feel rather doubtful as to its value. Increased precision is seen sometimes as a threat, sometimes as a triviality. At the same time there are fanatics who believe that they could completely revolutionize teaching results simply by using goal-analytic techniques more systematically. This division of opinion calls for a closer examination of concepts and empirical studies.

Systematic goal analysis is a process with several separate elements. The necessity of some of these elements may be debatable, but the process has a very palpable product: a definite series of goal descriptions (for a given field). This product will normally have an important role to play in guiding the development of a complete instructional system, as suggested above.

5.2 SOME POSSIBLE CRITERIA

We all have ideas about objectives in one form or another, and we have all been forced now and then to formulate these ideas. Occasionally, the term "goal analysis" (or "analysis of objectives") is used to describe these comparatively unsystematic attempts simply to write down or in some other way make explicit our ideas about goals. It would be preferable, however, to keep at least the term "systematic goal analysis" (and "systematic analysis of objectives"; we use these two expressions interchangeably in this context) for work which complies with certain standards. The question then is which criteria should be applied.

There is almost no common practice here to fall back upon, nor any indisputable authority. If we try to summarize various lines of development in current goal-analytic work, however (and primarily take up general criteria which can normally be applied in all fields), it should be possible to agree that at least the following criteria are reasonable starting points (cf. also the survey in Box 5.1):

(1) an empirical search for information as a basis for fixing objectives (it is not enough simply to try to formulate one's own goal concepts);

(2) a comprehensive search for information (taking empirical data from a single source normaly involves a risk of bias);

(3) collection of an empirical basis for giving priority to or evaluating possible objectives;

(4) firm rules for decision-making on the basis of the information gathered (a "firm decision-strategy");

(5) behavior-orientated precision in formulating goals (an important phase later is formulating the objectives in unambiguous, simple, communicable terms);

(6) a supplementary logical check;

(7) empirical goal checking (investigating how "realistic" goal specifications prove to be in concrete cases, assuming certain conditions with regard to resources and initial behavior);

(8) post-checking revision of goals (successive revisions can be made of goal formulations on the basis of the checking suggested in point 6).

Box 5.1 What does a systematic goal-analysis comprise?

There is at present no generally accepted norm as to which criteria are necessary and sufficient for a systematic goal analysis; and even partial analyses are naturally often worthwhile. Some important components in a more complete process are, however, as follows:

1. Search for goals
   - with empirical and
   - comprehensive methods,
   - providing a basis for priorities.
2. Focusing of goals
   - with firm rules for decision-making
   - behavior-orientated precision in formulation,
   - and checking that goal conflicts do not occur.
3. Adjustment of goals
   - with empirical goal checking: testing of "goal-realism",
   - and goal revision: successive, post-checking revisions.

The order in which the "criteria" have been placed here is at the same time a program, a sequence of work-phases within the framework of a complete goal analysis.

Many more sub-criteria can easily be formulated, and it is also possible to summarize the eight points above under more comprehensive headings. A comprehensive three-phase division could be formulated thus: (a) goal seeking (points 1-3), (b) goal focusing (points 4-6), and (c) goal adjustment (points 7-8). Phase 6-8 can also be excluded as a kind of supplementary work which is not always needed, and that leaves two main tasks: (I) to establish goals (points 1-4) and (II) to formulate goals (points 5-6). In the following sections some comments and examples will be given for some of the main points in the program outlined here.

5.3 GOAL SEEKING, GOAL FOCUSING, GOAL ADJUSTMENT - SOME WORK-PHASES OF A GOAL ANALYTIC PROCESS

5.3.1 Goal-Seeking: Empiricism and Comprehensiveness

The main aim in the introductory, goal-seeking phase is to obtain as comprehensive a basis for decisions as possible. Some obvious questions to start with are:

(1) How is a comprehensive basis for decisions concerning the X field of education to be obtained? What sources of information are to be consulted?

(2) Are there at present any obvious discrepancies between the statement of objectives and the realization of those objectives? Are there discrepancies between the demands made on objectives today and the demands that will be made in the foreseeable future?

Box 5.2 shows different ways in which these questions can be approached. The left-hand columns gives examples of a number of possible sources of information, divided into the main categories: texts, "practitioners", contact groups, teachers, students, and other members of society in general. The plus signs in the other three columns are intended to mark some of the cases where a survey of the particular subject-area suggests that information is primarily needed. The signs in the table are naturally only examples, although they have been chosen with a view to presenting a reasonable pattern. (The plus signs in brackets mark secondary sources; and the unmarked sections those which are not relevant here.) In the following we will refer to concrete examples - mostly from current Swedish work - of the various types of analysis.

Box 5.2 Goal-seeking: Examples of possible sources of information

Sources of Information	Present Situation		Future
	Actual	Desired	(Desired)
1. Texts			
1.1 Official documents (curricula etc.)		+	
1.2 Representative text-books	+		
1.3 International documents on policy		+	+
2. "Practitioners"	+	+	
3. Contact groups	+	+	
4. Teachers			
4.1 Representative groups	+	(+)	
4.2 Special-interest groups	(+)	+	+
5. Students			
5.1 Representative groups	+	(+)	
5.2 Special-interest groups	(+)	+	+
6. Other representatives of society			
6.1 Representative groups	+	(+)	
6.2 Special consumer groups	(+)	+	+
6.3 "Experts"	(+)	+	+
6.4 "Planners"			+

See text for more detailed discussion and explanations. Points 2-3 are of particular importance in the case of focused job-training, but less relevant in general education, e.g. in the comprehensive school.

Text analyses often make good starting-points, and in many cases the official documents are worth a closer study. An example of this type of text analysis (focusing on the demands made by society on graduate teachers) can be found in Löfqvist (1969). The official texts primarily describe the "desired present situation"; what it cannot give any information on is the actual present situation (which can after all sometimes differ considerably from the planned ideal). Moreoever, official plans are sometimes formulated in extremely vague and general terms. So additional, more precise information is often needed. A selection of the most frequently used textbooks can in many cases give more substance to the general outlines. They provide a picture which is often closer to the actual present-day situation. An example of textbook analysis can be found in Lindell (1969; focusing on the teaching of the German language to Swedish beginners). At the same time, it should not be forgotten that much of the content of the textbooks is there by tradition rather than as a result of planned analyses (Tingsten's stimulating analyses of textbooks in history and geography show how old traditions often cling with remarkable tenacity in school books that are frequently reprinted; Tingsten, 1969) and that those writing the textbooks have not always fulfilled the aims set out in the curriculum. So a textbook analysis can usually only be yet another small part of the goal-analytic whole. In some fields, documents stating international policy have been issued and may help to clarify the desired trends of development.

One central source of information is those people who can be grouped together under the general heading "practitioners": those who, to a large extent, practise skills and apply knowledge within the subject area with which the analysis is dealing. When training for a particular job is being studied, then naturally the job in question is the main object of interest; in many other cases the group is not so clearly defined. Several different methods of collecting data are possible: spot questioning (by interview or questionnaire), personal reporting for a specified period ("diary method"), or direct and detailed observations of behavior. Some of the main questions arising are: Which skills in the field seem the most essential for an adequate total pattern of behavior and for an individual feeling of fulfilling a function well, and on what points do the "practitioners" feel their basic training to be inadequate? In many cases interesting material is revealed by questioning the persons closest to the "practitioners" ("contact groups"). This applies particularly in studies of job-training for professions specifically involving contact with others. Studies of "practitioners" and "contact groups" are central to what is known as the B Project in our department, a project based on job-analyses of school-administrators, lecturers in teaching method and tutors (see e.g. Gestrelius, 1970).

Both teachers and students -- those directly involved in teaching -- are natural sources of information in many goal-analytic contexts. What in fact are the central ideas on objectives in the teaching world today and what changes seem most urgent? There are two ways in which teachers and students can be studied: either by picking random samples of individuals (perhaps primarily in order to get a cross-section picture of the actual situation, such as it is experiences by representatives of both categories), or by specially choosing groups of people with a particular interest in the subject-area (and then perhaps primarily in order to obtain a broad outline of the changes needed). A study of student's preferences in the choice of material is reported, for example, in Lindsten (1969). This aspect can be named "student-centered need analysis." Swedish commissions on schools have sometimes made use of this type of need analysis (see Härnqvist & Grahm, 1963).

Representatives of society outside the circle of "practitioners" and outside the school world should also frequently be given a chance to make themselves heard -- especially when we deal with final objectives. Random samples can perhaps also be used for this occasionally, but it is more usual to approach special "consumer" groups (the prospective employers or the institutes for further studies). "Consumer analyses" have actually played a not unimportant part in the work of Swedish commissions on schools; Urban Dahllöf's work on "Gymnasium" education is an obvious example (see Dahllöf, 1965; cf. also Husén & Dahllöf, 1960). A similar approach is often needed in projects on the development of material (see e.g. a study of foreign language requirements in sections of the Swedish business world in Larsson, 1969). This aspect -- in contrast to the student-centered need analysis mentioned above -- can be called "society-orientated requirement analysis". In addition, it is often valuable for those constructing material to be confronted with some kind of "expert group" at an early stage. These people may be experts in the subject (perhaps in the front-line of research with quite different ideas about what is and is not important than those suggested by conventional textbooks). But they could also be experts in method: people who have been particularly intensively engaged in teaching and in teaching innovations in the field in question. Goal-analytic work, based on "expert" opinions, was included in planning the broad outlines of the IMU system, a Swedish methods- and -materials system for individualized mathematics instruction (see Öreberg, 1966). When the main purpose is to gather ideas and suggestions from a group with a special interest, a suitable starting-point can be a conference with small group discussions, which different points of view are confronted, resulting possibly in a closer definition of concepts and a decision on priorities for partial objectives. - When it comes to future developments, information can sometimes be sought from variouscategories of people specially detailed to plan for the future, simply called "planners" in Box 5.2. Unfortunately, there are all too few persons of this type in the world of education today.

The catalogue of possible sources of information perhaps gives the overwhelming impression of this being an extremely long-term process. It should be understood, however, that these sources are hardly ever all used at the same time. In each separate case a decision has to be made as to which sources are the most important in view of the resources available and the problems to be studied. Often, however, it turns out to be more advisable to explore more than one source less intensively than the concentrate everything on a single aspect: it is easy to become biased if restricted to one single source of information. Some of the criticism directed at e.g. consumer analyses does not claim primarily that such analyses are unjustified, but rather that they are utilized too directly in the planning process without sufficient balance being maintained between different points of view. Similar criticism has often been made of those work analyses which only study the actual present-day situation; it is claimed quite rightly that additional information must be sought, on which desirable future models and objectives can be based.

Let us summarize some of the points covered above, tying them down more specifically to the self-instructional situation. We may then note that existing "source material" in the form of current syllabuses and text-books (so often used as the sole source of inspiration in programming) is valuable for analyzing objects, but -- and this is what we want to stress -- that the usefulness of such material should not be overrated If we rely too much on these sources, we may not make full use of our opportunities to increase efficiency. The shortcomings of these sources stem chiefly from two characteristics. Firstly, syllabuses and similar directions about instruction are often extremely vague and generalized in their formulation. Secondly, existing course material in the form of handbooks and textbooks not infrequently contains subject-matter that is quite extraneous to the objectives in question, being the result of chance, tradition, or personal interests of the author rather than of planned analysis.

In determining the necessary actions and knowledge ("terminal behavior" and "terminal knowledge") then, some of the better starting-points are: (a) an exact, detailed description by one or several experts in the subject, perhaps supplemented by a more extensive opinion poll, i. e. a study of so-called "consumer demands"; (b) a systematic observation of typical behavior in employees who are recognized as being good at the particular job that the course is designed to train people for. On which of these two approaches the main emphasis will fall, depends partly on the relation between manual-practical and verbal-theoretical aspects in the final result aimed at. As a rule, the more verbal theoretical factors there are (in a number of typical school courses these predominate), the greater the part played by descriptions by experts in the subject. The more manual-practical factors there are (and these would be frequent in many industrial courses), the better the information derived from observation. Systematic observations will often give a clearer picture of the frequency of various behavioral acts than an individual expert's statements. .

In choosing experts in a subject, it should be remembered that the constructor appointed probably often has sufficient qualifications to make an expert description. He was presumably chosen for his competence in that subject. But it is quite possible and often desirable that for this particular part of the work an even more highly qualified person, a top-ranking expert in the field, should be consulted. This applies especially to fields in which there has been rapid development in recent decades. In that case it may be only the outstanding scholar or scientist who has sufficiently good qualifications to state what is really fundamental at the time, without having to fall back on traditional material It has been reported that some of the physics books used in schools, for instance, still rely on nineteenth century physics at some points. Physics programming then should begin with an attempt to formulate what is essential and lasting, and this task should preferably be carried out by some one who is himself actively engaged in front-line research.

The expert in a subject, however, needs a certain amount of instruction in how to formulate his survey in such a way as to provide a practical basis for further work. Such instructions would usually be drawn up by a programming specialist in collaboration with the organization's own expert in the subject.

5. 3. 2 Forming a Basis for Priorities and Making Decisions

After the completion of as detailed and comprehensive a search for information as the particular purpose and the existing resources permit, the question still remains of how decisions are to be made on the basis of the information now available. It is quite conceivable that the total picture given by the information will show a considerable degree of conflict between the different sources (in the discussion of goals for universities, for example, the opinions of "consumers" and research workers often differ), or that the objectives outlined in official quarters are strongly at variance with what powerful tides of public opinion or objective observations deem reasonable. If this type of picture should emerge, it should not be the duty of the research worker to make the decisions or try to conjure away the difficulties; instead he should pass the information to the official decision makers most closely concerned, who will thus be given a more satisfactory basis - with all the facts on the table - for future action. It should be added, however, that such contradictory and unwieldy material is not often obtained. More usually, the various sources of information complement one another, and no real conflict arises between official objectives and the rest of the sources; instead the latter make possible concretion and specification of the comparatively vague and general terms of the official source. In such cases the collection of material has provided a considerably improved foundation for the work remaining to be done.

It is difficult to state general rules for the measures needed for forming a basis for priorities and making decisions, since in the actual transition from the collection of material to the making of decisions the measures vary considerably depening on the type of objective (partial or final) and the type of education concerned. In any case, it is important to decide on firm strategies. Up to now, however, relatively little systematic work has been done here -- within the no man's land between research-workers and politicians.

Normally it can be an advantage to keep the two phases clearly separate. Before deciding on priorities the research-worker or the worker in educational development must first gather information; this can be seen as a sub-task under the heading "goal seeking". In some cases the decision-making can be a fairly simple procedure with in no way farreaching consequences (e. g. in the case of sub-sections of a course area the general outline of which has already been decided, or when the available material is clear-cut); in other cases, on the other hand, it can have considerable political consequences and as a result involve quite different categories of persons. This decision stage is a sub-phase under the heading "goal focusing".

Sometimes the information needed on priorities emerges more or less automatically at an early stage. But it is often an advantage to collect as much comprehensive information as possible first, and then find out how it is evaluated or ranked by various interested groups. The main advantage here is that the evaluation or ranking can be carried out more comprehensively, once a primary basis has been obtained. This can mean that some of the groups named in Box 5. 2 are contacted twice: first to get spontaneous information on objectives, secondly to get from different points of view evaluations of (rankings of) lists of partial objectives, compiled on the basis of the first collection of data.

It is perhaps rather unusual to incorporate an "evaluation phase" separated in time from the primary search for information in this way. Concrete examples and more detailed arguments can be studied, however, within the framework, for example, of Project B, mentioned earlier (see Gestrelius, 1970).

5. 3. 3 Formulating Objectives

When it comes to formulating objectives, it has proved advantageous (a) to express the objectives in terms of behavior, and (b) to try to combine the formulation of objectives with the working out of "terminal tests" (final tests which contain tasks corresponding to all points stated in the objectives.

Many educational technologists now agree that an effective statement of objectives has the following qualities:

(a) It does not confuse description of courses (process description) with description of objectives (product description). A programmer with little experience is sometimes inclined to confuse the description of terminal objectives with the description of what happens while the course is in progress. This confusion may arise from the overoptimistic tendency to obscure the distinction between what the teacher goes through in class and what the student actually learns. Obviously, however, there may often be a considerable difference between what is "taught" (if by this is meant what is presented during a course) and what is "learnt" (if by this we mean demonstrable additions to or changes in the student's behavioral repertoire).

It is a somewhat trivial, but important fact that "initial behavior", "course process", and "terminal behavior" are three separate phenomena (distinct both logically and in time). Sometimes it is necessary to formulate "starting requirements". In that case we describe what the student must know before taking a certain course. In other situations there are grounds for formulating a "description of the course" (as often happens in a syllabus or a prospectus). But when, in planning self-instructional material, we have to draw up a "terminal description" we are attempting something quite different. Then we have to state what a student is able to do after he has completed the course (if the course functions the way we want it to).

To take an obvious example: The statement "The principles of programmed instruction are discussed on the basis of an historical survey and a detailed account of Skinner's theory" presents us with a "course description" ("process description"). A "terminal description" ("product description"), on the other hand, might look like this: "Should be able to describe at least three basic principles of programmed instruction and state at least two essential features of Skinner's theory correctly".

(b) The description of objectives concerns, to the greatest degree possible, observable (and thus clearly communicable and verifiable) conditions. It thus avoids terms which can be given varying interpretations by different readers. It is not enough, for example, to say that a student should know a law of physcis A, or that the should understand a mathematical argument B. We must try to explain how the student is to demonstrate that he "knows" A or "understands" B.

Many words commonly found in syllabuses are difficult to interpret unambiguously. Among the terms which occur very frequently, but which are somewhat ambiguous in the description of a course are words such as "understand", "know about", "appreciate". It is obviously not wrong to say that the student should "understand" a certain situation, but it is often not specific enough to provide a good starting point for preparing material. Unless we indicate some explicitly observable signs of comprehension, it is difficult for us to agree whether a student has attained the desired objective. Examples of words which have a more unambiguous meaning than those cited above are: "construct", "enumerate", "give examples of", "identify", "reproduce", "write down" etc. As a rule, then, such words referring to observable behavior, are preferred in our terminal descriptions.

Let us look at the following descriptions: (a) "The student should be able to appreciate fully Swedish poetry of the ´forties´." (b) "The student should have gained a complete understanding of the causes of the Cuban Revolution." Do these two statements satisfy the requirement of "communicability" set up above" Obviously not. None of them identifies clearly observable behavior. Strengthening additions (such as "appreciate fully,", "complete understanding") usually do not make it easier to give such statements an unambiguous interpretation.

(c) The description of objectives also states the prerequisites, which define more closely the demands made on the student´s behavior. We do not simply say, for example, that the student should be able to type out a French business letter. We must also state if he is to be able to do it both from oral dictation and from a handwritten manuscript (type of stimulus), if he is to be able to do it both on an ordinary office typewriter and on an electric typewriter (type of tool), if he is to be able to do it with or without the help of dictionary (type of aid permitted) etc. (Among other things, a clear definition of the stimulus situation is important in order to prevent what unfortunately often happens: that we unconsciously lower our standards and make do with indirect stimulation of the type verbal answer to verbal stimulus instead of a more direct response in a complicated concrete problem situation.)

We distinguished above between a volume of knowledge which is activated "spontaneously" (that is with minimal cues) and a volume of knowledge which is only activated when a choice of specific alternatives is to be made. A given series of alternative answers is an example of o one kind of situational prerequisites and such prerequisites - if they are acceptable to our purpose in the course - should be stated in the description of objectives since their acceptance in fact makes the objective different. The behavioral requirement can usually be made quite clear by using such phrases as "Without a dictionary the pupil should be able to ..." ("aids"); "Using log. tables the pupil should be able to ..."; "If the pupil is presented with a list of ..., he should be able to identify..." ("alternative choices given"), etc.

One method of checking to see whether the situational prerequisites have been made specific enough is to let someone go through a collection of test items in the subject-matter area and sort them into two piles: those covered by the given description of objectives ("the plus category") and those not covered ("the minus category"). If there are too many test items in the first category, more than the programmer intended, orif there is considerable hesitation in making this classification, then the description of objectives must be made more specific (i.e., more restrictions must be introduced). If there are too many test items in "the minus category" (more than the programmer intended), then the description of objectives must be made less specific (the number of aids allowed must be increased, etc.).

If such a check is to work satisfactorily, we must assume that the programmer himself knows precisely what the goal is. In other words, in this case the check does not apply to the suitability of the goal, but only tests how well the programmer has succeeded in making his goal clear to others in his terminal description. If the check works out well, we may say that we have adequately described the conditions necessary for excluding irrelevant student behavior (behavior that cannot be taken as evidence of the goal having been attained). Nor have we excluded too much.

(d) As soon as we are dealing with a continuum of possible achievements in the relevant behavioral field, the description of objectives should give a "pass criterion", or liminal value, i.e. the lower threshold value which the student ought to attain. What is meant, for example, by typing out an English business letter? What demands do we make on speed? How many errors are we prepared to tolerate? (This demand for a clear statement of liminal values constrasts strongly with the numerous expressions to be found in traditional curricula, such as "some knowledge of ...", "deeper knowledge of ...".)

Such as threshold value or "minimum for success" can be expressed in many different ways. Tow of the most common are to state a time-limit or the error tolerance. The error tolerance in turn may be expressed either as an acceptable deviation from a certain standard ("negative formulation") or as the smallest percentage of a given series of problems which the student should be able to solve ("positive formulation").

(e) Finally, the description of objectives is inclusive; it must not exclude any part of the total goal area, even if one particular part should prove more difficult to formulate in terms of specific behavior. Non-cognitive (e.g. attitudinal) objectives can sometimes be difficult to describe precisely; this fact must not be used as an excuse for not including them in the goal-analytic phase.

If another person conversant with the subject can, after reading the description of objectives and seeing the test results of a number of students, state which of these students have succeeded in attaining the objective and which have not, and if this person's classification of the students agrees with that of the person who drew up the description, then the description has been successful in communicating the objectives unambiguously, and the main purpose has been achieved. If this is not so, then communication has broken down. The various features of a good description referred to above are neither absolutely essential in themselves, nor necessarily entirely adequate. However, experience has shown them to be useful aids for increasing communicability. It might therefore save time and trouble to bear them in mind.

5.3.4 Logical Goal Analysis and Other A Priori Checks

As one sub-phase within the process of "goal focusing", we might wish to include a "logical goal analysis" for the purpose of studying the final formulations of the various goal components in relation to each other. Difficulties can arise, for example, if some objectives conflict with others. In such cases of conflict, the person responsible for analyzing the objectives usually has to refer the question back to the decisionmaking level for a new decision on priorities. A preliminary logical analysis is naturally made during the goal-seeking stage, e.g. in the text analyses, but the final logical check should be made at the same time as the descriptions of objectives are given their final form. - Other a priori checks can also be made, e.g. expert opinions on how realistic the descriptions of objectives are in the light of earlier experience of the target-groups in question.

5.3.5 Adjustment of Objectives: A Posteriori Checks and Revision

In one sense the goal-analytical work is complete once the final version of the objectives has been precisely defined and operationalized in the form of a terminal test. After that it is up to the teachers (or the constructors of instructional materials) to attain the objectives. If the first attempts achieve little success, it is usually not the objectives that need revising, but the methods or time schedule. Normally a teaching system cannot be considered ready until the given objective has been reached.

The chances of carrying out this ideal strategy, however, depend largely on resources: time for teaching and time for systematic improvement of methods. There is a strong possibility that in some cases (and despite what is above called a priori checks) we have aimed unrealistically high and that a revision of the levels of the objectives is well-motivated. Resources can also change in a way not predictable at the start, such as when the time alloted to a course is reduced. (Even though one in principle does not want to accept the present all too dominant role played by time schedules, there are naturally often sound reasons for this kind of limitation of resources.)

The normal techniques for checking the quality of methods and material in a new teaching system can in some situations also be used to check how realistic the objectives are, allowing for a certain initial level in the target-group and certain resources. If empirical tests of this kind suggest that the level of the objectives is unrealistic, then it may be necessary to revise the objectives and undertake new tests.

It would take too long to discuss this supplementary work in detail; what has been said above must suffice to make it clear that work on goal analysis can also involve a gradual adjustment of objectives, making use of empirical feed-back.

5.4 A FEW QUERIES

It is obvious that often when people say that they are carrying out goal analyses, they are in fact only working with a relatively small part of the spectrum of tasks outlined here. The reasons for this are sometimes sound; on other occasions they simply seem to be unaware of the opportunities available.

Among the influences which have served to bring goal-analytical work much more noticeably to the fore in general educational discussions, is the interest in programmed instruction and in systems of educational technology (see e.g. a "classic" like Mager, 1961, or discussion reports like Popham et al., 1969). But the point that is most heavily stressed in these contexts is often the precise formulation of objectives. It seems very reasonable (and there have been experiments on this, too) that the process of instruction can be speeded up if teacher and students have a clearer idea than is usually the case of where they are going; irrelevant behavior then tends to diminish and the student trains more intensively what is later going to be tested. On the whole, this emphasis on the value of formulated objectives as an instrument of guidance and focusing has had a very beneficial influence on both the general discussion of objectives and the work being done on systems of material and methods. Nevertheless, it is surprising how indifferent some of those urging the need for precision can sometimes be to the relevance and significance of the given objectives seen from other points of view. In such cases our criterion 5 (the formulation of objectives) has been allowed to weigh so heavily that there is a risk of other points of view (the seeking of goals and decisions on goals) being neglected entirely. This state of affairs has led to some rather strange contributions to educational discussions, which sometimes give the impression that one is forced to choose between precise trivialities or diffuse but significant objectives. If it could be made clear that the setting up of objectives and the formulation of objectives are two stages -- both very important -- in one and the same goal analysis, then the debate would become less muddled.

There are other examples of an unhealthy bias. The demand for empirical foundations has among other things resulted in extensive and extremely useful consumer analyses being made. These analyses have sometimes, as was hinted above, aroused criticism. This criticism has occasionally been expressed in political slogans ("we shall not let education be manipulated by the business world and high finance"), but has all the same contained an important core of insight, namely that objectives should not be set up on a one-sided empirical basis. Short-term utilitarian perspectives (dredged from consumer analyses) should naturally not dominate educational planning to such an extent that we deprive ourselves of the chance of developing completely new ways of achieving such a reconstruction of society which we agree to be desirable. Fundamental values must in some way be inserted in the equation, so that we are not tempted to equate consumer analyses with educational planning. The work carried out on consumer analyses has been very important, to some extent pioneering, but those interpreting it have perhaps on occasions been over-eager in generalizing the results. They then strongly emphasize our criterion 1 and at the same time tend to forget criterion 2, which balances it, and are not always particularly interested in the other criteria.

Considering these various tendencies towards what has here been called one-sidedness, the following question seems self-evident: If we accept the criteria given above as a description of a complete, systematic goal analysis, to what extent does this paragon actually exist in our hurried and stressed environment? This question would be worth studying more closely, but at the present time the answer would probably be that such complete analyses are at least not common. And what then is the reason for this? One important factor is naturally that the technique is not widely known. But can there be other reasons? Is their value perhaps doubted when considering the amount of work involved?

In fact, this field, which has attracted increasing interest and activity, contains a whole series of subjects suitable for research and developmental work. It would be of interest, for example, to set up a series of alternative models for goal-analytic processes and for statements of objectives. Many questions then follow naturally: How common are the various models and the various types of goal descriptions in different educational developmental contexts? What goal concepts and goal descriptions exist at present in the sphere of practical education (among those working on curricula writing textbooks and training teachers, among administrators, teachers and students)? In what ways do these goal concepts and goal descriptions differ from the norms most commonly recommended by experts on goal analyses? Which advantages or disadvantages do various categories see in the more exact methods? Which arguments occur most commonly against the use of increased precision? And to what extent can one show, by means of experiments, clear-cut effects of strict goal analyses in various practical situations?

This problem area of goal analyses, so hastily touched upon here, is of central importance and can have practical consequences for several aspects of educational planning. There is good reason, therefore, for making it the object of further conceptual analyses and discussion and increased empirical investigation.

5.5 SPECIAL AIDS: TERMINAL CHARTS, TERMINAL CARDS, AND TERMINAL TESTS

It is often helpful to describe "terminal requirements" in the form of a "terminal chart" (or a series of "terminal cards") and a representative "terminal test" based on these.

A "terminal chart" is simply a system of squares in which the horizontal rows represent the desired objectives and the columns give the special conditions in which the student should be able to give evidence of the behavior in question, e. g. (a) the reference works or aids with which the student should be able to solve the problem and (b) the degree of proficiency with which he should be able to do it.

The appearance of the chart will vary considerably depending on the particular subject-matter dealt with, but some of its major aspects are illustrated in Figure 5. 1.

A few examples. If the terminal behavior is the ability to work out a correlation coefficient of a certain type, the question of "aids permitted" is important when presenting the course material. Under some circumstances (if it is a question of fairly advanced statistical work) we may require the ability to make these calculations without any aids at all. In that case we put "0" in column A in the table and then we must make sure that the study material gives the student the kind of training that will enable him to work out these coefficients independently and confidently without using formulae or models. In other cases perhaps we only require the calculations to be made with the aid of formula. In still other cases, when a job requires less independent calculations, we do not even ask this much, but only that the student has a certain amount of practice in following a step-by-step model. This model then comes under the heading of "aids permitted".

In many tests of proficiency, the speed of working (column B) is very important. We do not convey much information if we state only that a pupil should be "able to transmit a Morse telegram" or be "able to receive a Morse telegram". An indication of the minimum requirements for the transmission speed and the receiving speed (e. g. , the number of signs per minute) would be much more to the point.

The error tolerance to be allowed (column C) must often be considered together with the requirement of speed. In several cases, absolute perfection is so essential that the error tolerance must be considered 0. This applies, for instance, to certain instrument readings in flying an aeroplane, where even slight mistakes can endanger life. In other cases, of course, we can be a little more tolerant, e. g. slight spelling mistakes in typing a running text.

As the number of terminal objectives is often large, and as it may be useful for further work to have descriptions of these terminal objectives in a form that readily allows rearrangements, additions etc. , it is often convenient to work with "terminal cards", at least initially, instead of a fixed "terminal chart". Each card then corresponds to a

Specifier Terminal behavior	A Conditions given (including aids permitted)	B Minimum speed	C Maximum error tolerance
T_1			
T_2			
T_3			
⋮	⋮	⋮	⋮
T_n			

Figure 5. 1 Basic principles for a "terminal chart"

horizontal segment in the "terminal chart". The card should thus include the same data as is contained in one row of squares even though the information need not necessarily be presented in the same format (column distribution).

To obtain further guidance for the construction of the study material and to get clear-cut instruments for estimating the effectiveness of the material from the very start, it is useful, even at this stage, to draw up a representative "terminal test", i.e. a series of tasks containing sample tests of the proficiency and knowledge which the student is expected to have acquired in the terminal situation. The "terminal chart" and the "terminal cards" provide the basis for the construction of the test. All the essential part objectives will normally be represented in the test; the conditions given (including aids), the requirements of speed, and the error tolerance should be taken into account.

6. STUDENT ANALYSIS AND SITUATION ANALYSIS

6.1 STUDENT ANALYSIS

The basic analysis of prerequisites also includes a student analysis, i.e. a survey of the special characteristics of the intended target population. We have particular reason to study the students' "initial repertoire" (the behavioral repertoire they take to the study situation: previous knowledge and existing skills etc.) and their probable "medial situation" (the experiences that await them and the opportunities for training which are available between the study situation and the terminal situation proper.

6.1.1 Expanded Terminal Chart

The result of the student analysis should preferably be incorporated into an "expanded terminal chart". The data on the target population are introduced as extra "specificators", which provide further information on the prerequisites for the training course. As shown in Figure 6.1, these data can, for example, be placed in a Column D ("initial prerequisites") and a Column E ("medial influence").

The initial prerequisites we are thinking of here are primarily previous knowledge and already existing skills (certain other prerequisites will be mentioned further on). When the entire target population has certain pre-knowledge, significant cuts can naturally be made in the study material. This often happens in courses for adults, which recruit people with basic vocational training. When a large part but not the entire target population is thought to have previous knowledge, a special "supplementary course" is needed for these who have no previous knowledge and in addition a "filter test" to extract this group, in the cases when it is not obvious in advance.

Column D ("initial prerequisites") is thus concerned with the past. An assessment should be made for each separate desired terminal behavior, stating to what extent it may already exist as initial behavior for the target population as a whole or in part.

Column E ("medial influence") attempts instead to take a look at the future. In some cases the individual's ordinary occupation (which he practises between the study occasion and the terminal situation) makes it easier for him to retain the knowledge acquired. In other cases, however, it can make it more difficult for him ("interference"). A probability assessment of this is made in Column E. To what extent does "medial behavior" (the existent behavior between the study situation and the

Specificator: / Terminal behavior:	A Conditions given (incl. aids permitted)	B Minimum speed	C Maximum error tolerance	D Initial prerequisites	E Medial influence
T_1					
T_2					
T_3					
⋮	⋮	⋮	⋮	⋮	⋮
T_n					

Figure 6.1 Expanded terminal chart

terminal situation) reinforce the desired terminal reactions? To what extent does it interfere with the retention of skills? Any attempt to make such an assessment on the basis of acquaintance with the target population can often of necessity be no more than approximate.

Let us suppose that we are dealing with behavior for which the terminal situation is mobilisation and the study situation a military course. If the particular target population consists of people who can in their normal occupations maintain the acquired skills, then we can say that the medial behavior forms a supporting connecting link between study behavior and terminal behavior (and we might signify this with "++" for "strongly supporting" and "+" for "rather strongly supporting" when it comes to individual skills). In many cases the medial behavior is neither supporting or interfering. We then put "0" in Column E and perhaps count on the acquired knowledge and skills gradually diminishing as time passes.

Finally, in other cases we must take interference into account. It can be a question of individual skills: e.g. if two different methods of notation are used in civilian and military practice, or if the students use two different shorthand systems (one in the study and terminal situations and another in the medial situations). But it can also involve more general behavioral roles connected with a certain position in society. A man who in his everyday life is used to leading others and acting independently naturally often finds it more difficult than someone who has a more subordinate civilian position to enter into the role of the submissive and obedient private soldier, which he practised for a few months in his youth and which he is expected to resume in the event of mobilisation. -- The idea of having the right man in the right place in a mobilisation context means -- using our present terms -- making sure that the "terminal role" and the "medial role" are mutually "consonant", so that the medial behavior becomes a reinforcing factor rather than an interfering one. In many cases, however, general role dissonance or special behavior dissonance must be accepted as unavoidable and this should then be marked in Column E (e.g. with one or two minus signs to denote a lesser or greater degree of interference), and then measures must also be taken in the training situation to make the effect of the training maximally resistant to interference.

The interference phenomenon can sometimes occur simultaneously as an "initial prerequisite" and as a "medial influence" and thereby have an increased effect. This kind of dual-effect often has to be taken into account, for example, in the teaching of foreign languages. An English student comes to the course in French or German with deep-rooted

English language habits, including patterns for the combination of language categories, a set of well-trained sounds and special intonation series. Some of these combination patterns, sound and intonation sequences are parallel in the student's mother-tongue and in the new language. These cause relatively little difficulty. In other cases, however, there is a lack of agreement and this is where the established language habits make learning more difficult. This interference continues both during and after the course, since training in the mother-tongue goes on all the time.

Opinions are divided on the best way to counteract the effect of the interference factors. No-one can deny, however, that they do exist and that they exert a strong influence. This is shown most clearly in the fact that school children from different countries make very different mistakes when learning a particular foreign language. This should in its turn mean that when training any one language, the main emphasis should be placed on different points for different groups of students (representing different language areas or sometimes even different dialectal regions).

Linguistic interferences should, therefore, be considered a matter of central importance when self-instructing aids are being constructed. For that reason it is often advisable, when working out courses in foreign languages, to use a slightly different form of expanded terminal table, where the interference phenomen is given a separate column. It is naturally possible to learn languages with the help of courses which have not been adapted on the basis of existing interferences. The courses which are often arranged in a country for mixed groups of foreigners prove this, as do the cases when a course originally intended for use in another country has been "borrowed". There is reason to believe, however, that this often leads to a considerable loss of efficiency. Some students are given unnecessarily long training on points which cause them no difficulty, while others get far too little practice on the items which are the most problematic for them. (For further reading in this particular field, see a bibliography with the title, "Contrastive studies in linguistics", Gage, 1961; see also Lindell, 1969.)

6.1.2 "Modified Terminal Test"

The expanded terminal table should also lead to certain modifications being made in the terminal test. The types of behavior that can with certainty be said to exist as initial behavior in the student group in question naturally need not be tested, but can be omitted from the test. This means that the data in Col. D must be taken into consideration. Furthermore, we must often try to estimate the immediate effect of a particular study material, even when the terminal situation is remote in time. In that case we must also, when constructing the test, heed the circumstances stated in Column E, together with the interval of time which is relevant in this context. Thus the immediate test becomes a "pseudo-terminal", and it is often reasonable to make these immediate demands somewhat higher than the terminal table otherwise declares to be necessary.

Some readers perhaps think that this two-stage procedure (first establishing a terminal table in purely general terms and a subsequent terminal test and then a terminal table extended on the basis of student analysis and a subsequently modified terminal test) is unnecessarily circuitous. Would it not be just as easy - with some general information about the student group - to concentrate directly on the second stage of the goal-analysis? There are naturally quite a lot of cases in which the use of this shorter procedure is plausible.

There are two main arguments, however, in favor of a frequent use of the more detailed two-stage procedure. The process becomes more explicit, which reduces the risk that hitherto unexplored possibilities are neglected simply because of tradition (the usual pattern for teaching a particular student group, e.g. a particular age group). Secondly, it is not necessary to start working from the beginning again as soon as one wants to build up a new course in the same field for another group of students (the first stage remains intact, as a foundation for future work).

6.1.3 Further Points to be Considered in the Student Analysis

So far we have for the most part only discussed student analysis from the point of view of concrete previous knowledge in the field to be dealt with in the course. The student naturally has many other important sides, which should as far as possible be known and taken into consideration from the start, when the course is being planned. Examples which can be given are the students' level of intelligence, reading ability, general background experience (which can then be used continuously for illustration and association), together with their purpose in studying (and subsequent study-motivation).

Some early studies (see e.g. Little, 1934 and Porter, 1959) seemed to show little connection between the intelligence of the students and the results they achieved in programmed teaching. This gave rise to optimistic ideas that programmed teaching would wholly eliminate the significance of varying levels of intelligence in learning. The only difference would be in the length of time taken to learn by those with greater or less ability. The correlation between intelligence and student results in current teaching was seen as an expression of that teaching's instructional inefficiency: what a student got out of a course depended most on what he "took with him" to the course. It was thought that if the course were planned more efficiently, it should communicate its message regardless of the level of intelligence of the students.

Experienced teachers found it difficult to accept this excessive optimism and later studies (e.g. Silberman, 1961; Shay, 1961) seemed to show that the conclusions mentioned above were premature. Naturally, the individual rate of work and the student-guided flow of information can result in the disappearance of some "unnecessary" failures. The inability to grasp an account quickly should have less significance in the use of self-instructing study material than in conventional teaching. But the idea that general intelligence should suddenly, as if by magic, cease to have any relation to the ability to learn must, for the time being, be dismissed as wishful thinking.

The significance of this in more concrete terms for the planning of courses is partly, that the average intelligence of the target population must be taken into consideration both in the wording and in deciding the "density of information" (more about this in a later context), and partly that an attempt should be made to judge whether or not the target population is very heterogeneous with regard to intelligence. In many cases those taking part in a course form a relatively homogeneous group and then there is usually no reason for working with parallel courses. In some cases, however, the variation is exceptionally great. It can then be worthwhile to consider either parallel courses with varying degrees of "information-density" or a course with branching (e.g. with additional built-in repetition for those students who prove to need this). This point will be discussed further below in connection with the concept of "flow-model".

Reading ability, perhaps in particular the command of vocabulary, is obviously of great importance if the student is to be able to assimilate a certain study-material. Even the ordinary text-books are usually carefully adapted to the reading ability of the target population. But in self-instructing material this aspect is of even greater importance. Here, unlike in ordinary classroom teaching, there is no teacher available to explain the parts that are difficult to understand. Reading comprehension tests for representative groups of the target population can in this context play a useful part at the planning stage. This question should naturally also be kept in mind during the successive testing of the preliminary version.

Acquaintance with the general background experience of the students is important because it makes it possible to provide meaningful illustrative material and "correlative stimuli" (to make use of the terminology used above) which promote learning.

Certain series of associations are natural in some "symbol environments", but completely foreign in others. If one is acquainted with the target population's common symbol environment (determined partly in an adult group by education and vocational experience), then it is easier to formulate the teaching material in such a way that it fits in with the conceptions the students already have. This is the best way of using the "net of associations" which the students have already acquired to bind the new material in the "repertoire of associations". If possible, one should try to get some idea of the natural "symbol environment" at the preparation stage and then all later revision work should obviously be guided in part by how well one has succeeded in making use of the student group's background experience.

The target population's particular purpose in studying is naturally of significance for the level of motivation. If there is no real personal purpose behind the studies, i. e. if they are compulsory, it may be necessary to incorporate special measures to promote motivation. In such cases, it becomes even more important to associate to the student's own experience and to use examples which make him feel that the material can - despite everything - be relevant to him personally. Sometimes an item should be treated from different angles for people with different study-purposes and different interests. If such groups with clearly separate interests occur within the student-group in question it may be necessary to construct parallel versions of the course material for some sections of the course (for more on this, see below). In general, the main aim - both when the group is relatively homogeneous in purpose and when various sub-groups have different purposes - should be to make the study material as "consonant to purpose" as possible. If this is done consciously and according to a clear plan, there is a greater chance of achieving positive gains in motivation and thereby also making the process of learning more efficient.

Less essential - but not without importance in some contexts - is the fact that the purely external form of presentation can create an interest in studying which the study-material in itself does not provide. An example of this is the mechanical form of presentation which, by the process of manipulation involved, creates an additional interest in the same way as a gambling machine. The most important thing is naturally always to make the study-material interesting in itself, but these elements used to heighten interest should not be despised if they really prove to be effective and are at the same time easy to produce. Often it is not the mechanical manipulation in itself which is interesting, but the fact that the machine gives continual information on what has been achieved. Like an automatic target, it shows immediately - sometimes by means of a dramatic light or sound signal - how an attempt to solve a problem has succeeded. The value of such obvious praise-signals for the motivation of students who are nervous and anxious to succeed should not not be underestimated. But naturally the individual differences should not be forgotten here either. A process which amuses and heightens the motivation of a boy in the lower forms of the comprehensive school can very well be an unnecessary source of disturbance and irritation to an educated adult with a clear purpose in studying, who is used to dealing with complicated tasks independently (without the support of someone who shouts 'Bravo!' at every stage).

To summarise, the main questions which anyone constructing study material must ask himself in connection with the student analysis are: a) Does the group have "previous knowledge" which makes some of the items included in the goal-specification unnecessary? b) What limits do the general intelligence and reading ability of the target population set for the degree of difficulty which can be used in presenting the material? c) In what way can knowledge of the students' background experience and purposes of study be used to make the material more efficient? d) In what way must the nature of the "medial situations" (what the student does in the interval between the study-situation and the terminal situation proper) be taken into consideration when the course is planned? e) To what extent can an analysis of probable "interferences" help us to pick out the items in the course which need most practice? f) Does the student-group vary in different respects - intelligence, reading ability, background experience, purposes of study etc. - to such an extent that parallel courses or courses with different branches become necessary? We may also at this later assessment be forced to accept that some parts of the content of the goal-specification are too difficult for some section of the student-group.

6.2 SITUATION ANALYSIS

We should, on the basis of the prerequisites given us by the goal analysis and the student analysis, try to create an adequate external teaching situation. If on this basis we can decide upon the most effective forms of presentation, we can acquire the aids we need in order to present the material in this particularly effective way. And if, on the basis of goal analysis and student analysis, we can establish the time needed to reach the goal, then we can use this in deciding the time-structure of the course. Etc.. In other words, we let the external organisation of the teaching situation emerge naturally from the analysis of what is most rational instructionally.

The educational "rationalisation expert" seldom works, however, in an environment that is so flexible that he can immediately have all his wishes fulfilled; no matter how well-documented they are. On the contrary it is usually so that financial resources, available aids and specified lengths of time for courses are already fixed or can in each case only be influenced to a limited extent at the moment when the course is being planned. While plainly declaring what in his opinion would have been the most rational procedure, he must nevertheless see it as his task to make the best possible use of the resources available (in the question of time, aids and money, for example).

This means that an analysis of these external restrictions on the use of the study-material must also be included in the original preparatory work as factors to be remembered in the final selection of material and in assessing which presentation media etc are economically feasible. But these assessments should be kept clearly separate from the more rational considerations.

External restrictions must not gain such a foothold in the construction of the course that accidental circumstances at the beginning of the course gradually become tradition and are afforded the status of definite principles. This is possibly one of the greatest difficulties involved in constructing self-instructing material. The course must often be started in a very special "compulsory situation". The work of constructing the material is extensive and costly and one has no desire suddenly to tear up what one has created. And then as a result one has perhaps helped to preserve an unfortunate initial situation instead - as the intention was - of making a contribution to the continuing pedagogic development. If only one is aware of this danger, however, it should be easier to avoid it. One way is to keep a special record of emergency measures

measures taken because of external organisational circumstances, not based on rational pedagogic considerations - and then to use the record continually in the battle for a more rational state of affairs. This also leads naturally to revision of the working program as soon as this battle succeeds on some front.

7. SUBJECT-MATTER ANALYSIS

The analysis of objectives gives a general survey of the terminal behavior which a specific instructional material is intended to lead to and involves thereby, at least implicitly, a preliminary delimitation and determination of its content. But before proceeding from this first delimitation to the actual writing of study material, however, a more detailed analysis of the subject-matter should normally be made. The main purpose of this analysis is to obtain a more thorough understanding of the logical and psychological structure of the subject-matter, with a view to deciding on the most effective instructional presentation.

The detailed procedure of this analysis must differ to some extent from case to case, depending on the general aim of the particular course and the suitability of the subject-matter in question for a particular analytical procedure. The following description, therefore, gives only an example of a method of evaluation which can be useful in this connection. It should be added that in certain cases it is also possible to proceed more directly from the analysis of the objectives and the analysis of the students to the writing of study material. While a detailed goal analysis is almost always necessary, a subject-matter analysis of the type we shall illustrate here should be regarded rather as an aid and check than as an absolute necessity.

7.1 EXAMPLES OR PROCEDURES FOR ANALYZING LOGICAL STRUCTURE OF CONTENT

An analysis of the logical structure of content is obviously most easily applied to those subjects in which the logical structure is relatively fixed and fundamental. This is especially true of mathematics and certain scientific subjects. But sometimes this analysis can be more useful for subjects in which the logical structure is not so readily apparent in our conventional textbooks. In the latter case it is sometimes possible to make a radical improvement, after a study of the central structure of the subject, by getting rid of much unnecessary and distracting matter which is neither relevant to the objectives nor fulfilling any clear function as "instruction facilitators" on the route to the goals.

Some natural stages in such an analysis can be: (a) working out a list of the basic units of the area covered by the course, usually "concepts"; (b) trying to arrange these basic units in a logically meaningful sequence, normally within a hierarchical system; and (c) studying other logical relationships between the basic units in order to choose such "relational pairs" as are particularly significant from an instructional point of view.

7.1.1 The "C-Catalogue" and the Preliminary "S-List"

From a logical viewpoint it is normally natural to break down the content of a subject into fundamental concepts (here referred to as "C") and statements of different kinds about these concepts (here referred to as "S"). In a course on grammar, for example, it would be reasonable to regard such terms as "noun", pronoun", "subject" and "predicate" as "C units" and a statement of the type "Nouns and pronouns can function as a subject" could be regarded as an "S unit" or "statement" as it is used here. The "statements" often express relationships between the basic concepts.

Among the advocates of a logical analysis of course material we can mention Evan, Homme and Glaser, whose analytical procedure is usually called the "Ruleg" system, since it is built up on "rules" and "examples". A number of ideas from the "Ruleg" system have been incorporated in the present discussion, but we have thought it natural not to limit the analysis to "rules" and "examples" (which are often relatively complex from a logical point of view) but prefer to start from somewhat more basic elements ("low-level units").

It is often expedient to have an expert in the particular subject area work out a detailed "C-catalogue" for the area delimited by the list of "terminal behaviors" decided upon. Every item of behavior in this list is examined, in this process, with the following question in mind: Are there one or more concept-units of which the students should have knowledge to be able to act correctly (and with sufficient flexibility)? Each item of behavior can imply a large number of different concept-units, but on the other hand, of course, a whole series of items of behavior may be connected with one concept or the same group of concepts. In other words, no one-to-one relationship exists between behaviors and necessary concepts. We should like to be certain that this analysis is made in a unprejudiced manner and without reference to current textbooks and similar study sources. The work at this stage should therefore be carried out as far as possible by experts at the highest level.

As a practical matter of technique, it would be an advantage if each separate concept were noted down (by means of a "key-word" together with any necessary explanation) on a separate card ("C-card"). The obvious advantage of a card-index here is that later on it will be so much simpler to handle the basic units when it comes to examining the relationships between them. This collection of C-cards constitutes the "preliminary C-catalogue" and thus implies a breaking-down of the total content into logical units.

Before this collection of concepts is used for structural studies, it would be advisable to check and supplement it by comparing it with existing source material in the field, as it is possible that the subject specialist may have overlooked certain significant concepts. But this "source confrontation" should be the second stage in the work, not the first. (If one starts from source material, one risks losing the advantage of the survey of essentials made by the expert and runs the risk of being unnecessarily restricted to traditional approaches.)

The the subject expert makes a "preliminary S-list", i.e. writes down the special relationships (rules or laws) which, in his opinion, should be taught (in order to prepare the students adequately for reaching the instructional goals listed).

7.1.2 The "Sorted C-Catalogue"

The next stage is to try to arrange these basic units in a logically meaningful sequence. One of the simplest and most natural ways of doing this is to systematize the basic units into a hierarchical system, i.e. by grouping the cards within a system of superior and inferior classification categories.

A simple procedure is as follows: The total content is divided up under a number (perhaps between ten and fifteen) main headings. In choosing the main headings, one is partly guided by an examination of the data from the goal-analysis and partly by going through the unsorted C-catalogue. The main headings are written on demarcating colored guide-cards, and the single C-cards are sorted under these different headings. Each of these main sections is then split up into a number of sub-sections, each with its own sub-title. The sub-titles are written on guide-cards of a different color and the C-cards then sorted into these smaller divisions. A further sub-classification is then carried out, in which a third color is used for the headings of these new sub-categories. This sub-dividing is continued as long as it appears to be fruitful for the particular material being handled. Finally, the individual cards are arranged in a logically meaningful sequence within each category.

The result of this procedure is that the logical basic units in the "Sorted C-catalogue" have been arranged in a hierarchical scheme of the general type, as shown in Figure 7.1.

As an aid to finding one's way quickly about the catalogue, one might use a predetermined color scale for the guide-cards, e.g. from "warmer" colors for the broader categories to "colder" colors for the more limited ones (in accordance with a suggestion by Mechner; cf. Glaser, 1962). Such working details are, however, a matter of individual preference, and are obviously of no critical significance for the main purpose.

7.1.3 "C-Matrix" for Exploring Relationships

It is convenient to number the individual cards in the sorted C-catalogue in the order which has been established. Starting from this fixed sequence, a "C-matrix" is then built up. This consists simply of a system of cells whose row and column headings are designated by the key-words of the individual C-cards. In other words, the key-words on the C-cards are entered in numerical order from top to bottom in the left-hand heading column of the matrix and in the same order from left to right along the upper edge of the matrix.

A cell in the matrix is taken as symbolizing all conceivable relationships between two concepts as shown schematically in Figure 7.2. The main diagonal is of little interest in this connection and has been marked with an X. The first row gives the relationships between concept C_1 and other concepts. The second cell in the first row thus gives the relationships between concept C_1 and concept C_2. In the same way, the third cell in the same row gives the relationships between concept C_1 and concept C_3, and so on. The lower left-hand half of the matrix forms a mirror-image of the upper right-hand half, in so far as the same pairs of concepts are repeated. For some purposes, however, the "direction" of the relationships is significant, and in these cases the two halves are not identical: in the upper right-hand half of the matrix the "first" component of each pair is the unit with the lower sequence number, while in the lower left-hand half the "first" component is the unit with the higher sequence number.

The main purpose of the C-matrix is to serve as a starting-point for systematic exploration of the relationships. The basic question which should be considered throughout the examination is: In this particular relationship such that it should be used for instructional purposes? The constructor can, for example, go through the matrix cell by cell asking himself: What connection is there between these two concepts, and is the connection of a type which can be used in teaching? Or perhaps he can ask: Is there a basic difference in character between these two concepts of such a kind that it can and should be used instructionally in preparing the study material?

A separate matrix could be used for each type of relationship one wishes to explore in this way. One would then produce a matrix book, in which the individual pages represent different types of conceptual relationships. Usually, however, such a procedure is unnecessary, and in many cases it would be of practical value to record the different types of relationship on one and the same matrix, so that they can be seen at a glance and readily compared. One perhaps decides first of all to mark with a "K" on the matrix those cases in which a certain type of causal connection is of instructional interest and with an "O" those cells in which a differential relationship is pedagogically interesting. At the same time one can decide to enter a "D" in the main diagonal of the matrix for concepts for which it appears specially important to give a clear and detailed definition. A C-matrix used in this way might after the exploration look like that shown in Figure 7.3.

A well carried out exploration of the C-matrix guarantees to some extent that the original sequence order according to the hierarchical pattern does not lead us to forget important and instructionally valuable relationships of other kinds. Thus the two ways of studying the material supplement each other.

7.1.4 Comparison Between "C. C-Cards" and the "Preliminary S-List"

Working from the C-matrix which has been marked up in the above way, the constructor makes a series of additional cards. Each of these takes up one of the conceptual relationships which has been marked on the matrix as instructionally interesting. The extra cards - called "C. C-cards" - are then compared with the previously mentioned "preliminary S-list". The latter can be regarded as a "C. C-catalogue" which is based on general teaching experience, but has not been examined in detail from a logical point of view.

A comparison of both collections should in many cases be instructionally rewarding. In a number of cases - especially when the subject material in current text-books has been logically well worked out - the difference between the collections is perhaps not particularly great, and the contribution of the C. C-catalogue is then more modest. In these cases it is primarily an extra check and confirmation that no important logical connections have been missed. In other cases - perhaps especially when there is relatively little instructional experience in the particular field - the differences between the two categories can be rather numerous.

A number of these discrepancies will probably indicate that certain of the statements recorded in the preliminary S-list have no equivalents in the C. C-catalogue. One should then ask oneself: Has this gap in the C. C-catalogue occurred because, in going through the C-matrix, one has omitted to record an important relationship (this kind of thing naturally does happen), or is the discrepancy a more important one? Must certain propositions in the preliminary S-list be considered, on second thoughts, hardly fundamental from a logical point of view and dealing with only superficial connections? But most often the majority of the discrepancies between the S-list and the C. C-catalogue will probably be in the opposite direction, that is, several relationships which do not appear in the S-list will come up in the C. C-catalogue. This would also be the most valuable result from the instructional point of view. Under optimal circumstances, such an addition can mean a really fruitful collection of suggestions for fresh pedagogical approaches.

In many cases the final step in this stage of the work would be to insert the C. C-cards (after possible corrections and additions through reference to the preliminary S-list) in suitable places in the "Sorted C-catalogue". A good method of doing this is, for example, to insert an individual C. C-card immediately after the C-card which describes the last component of the relationship (in other words, at the earliest point in the sequence at which both components have been introduced).

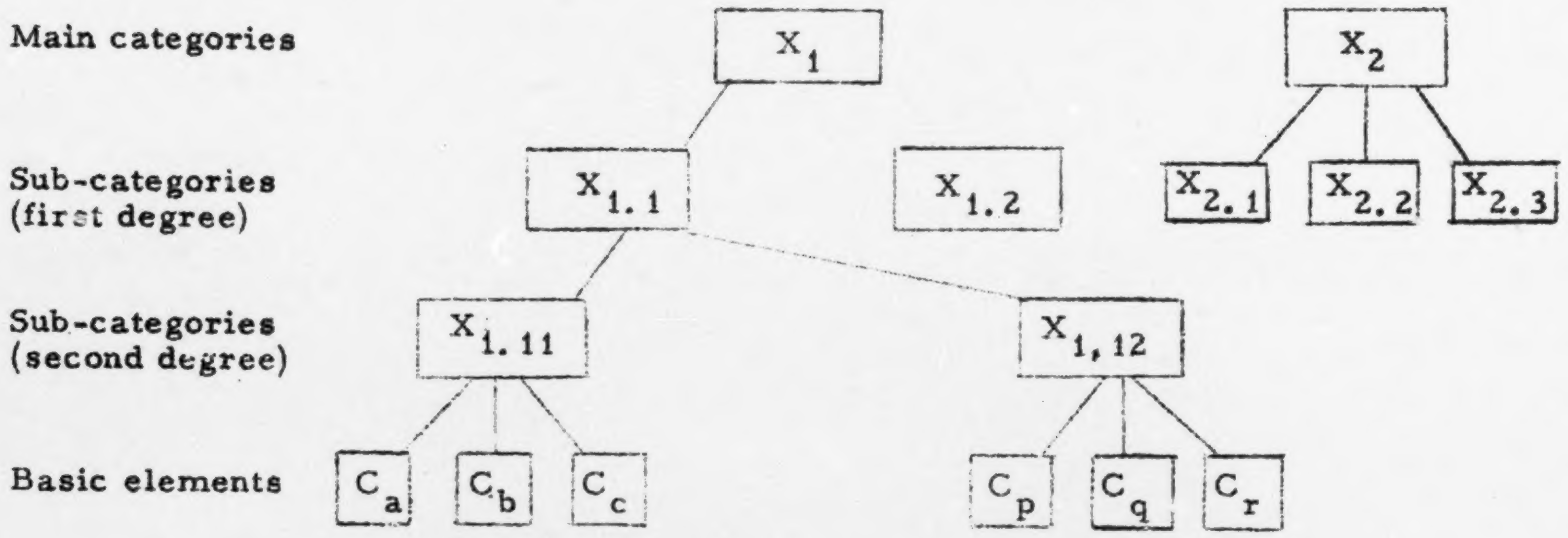
Main categories
Sub-categories (first degree)
Sub-categories (second degree)
Basic elements
X_1
X_2
$X_{1.1}$
$X_{1.2}$
$X_{2.1}$
$X_{2.2}$
$X_{2.3}$
$X_{1.11}$
$X_{1,12}$
C_a
C_b
C_c
C_p
C_q
C_r

Figure 7.1 Example of the principle for constructing the "Sorted C-catalogue"

Note: For the sake of surveyability, categorization has been completed for only a small part of the structure (proceeding from $X_{1.1}$)

	C_1	C_2	C_3	. . .	C_n
C_1	X	$C_1 - C_2$	$C_1 - C_3$	. . .	$C_1 - C_n$
C_2	$C_2 - C_1$	X	$C_2 - C_3$	. . .	$C_2 - C_n$
C_3	$C_3 - C_1$	$C_3 - C_2$	X	. . .	$C_3 - C_n$
⋮	⋮	⋮	⋮	⋮	⋮
C_n	$C_n - C_1$	$C_n - C_2$	$C_n - C_3$	. . .	X

Figure 7.2 "C-matrix": General characteristics

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}
C_1	D		K						K	
C_2		D				O				
C_3	(K)							(K)		
C_4				D		K	K			
C_5										
C_6		(O)		(K)					(O)	
C_7				(K)			D			
C_8			K					D		
C_9	(K)					O			D	
C_{10}										

Figure 7.3 An example of a C-matrix with markings for relationships judged to be important for instruction

Note: The marking of this matrix shows that the constructor considered it important

a. to give a detailed definition of concepts C_1, C_2, C_4, C_7, C_8, and C_9;

b. to use instructionally a certain type of causal relationship between concepts C_1 and C_3, C_1 and C_9, C_4 and C_6, C_4 and C_7 etc.; and

c. to use instructionally differences between concepts C_2 and C_6, and between C_9 and C_6.

7.2 SOME REFLECTIONS ON PSYCHOLOGICAL SUPPLEMENTATION OF THE LOGICAL ANALYSIS

Some readers may perhaps by now have a feeling that the treatment of material we have just described places far too much stress on logic, and are perhaps inclined to object that it is not after all the logical approach that is most important. The essential thing is to present the material in a psychologically suitable and instructionally effective way. It is not at all certain that what has been broken down to its logical essentials is necessarily the most effective type of material for teaching purposes. Is there not a risk of involving ourselves again in a "pedagogical logicism" corresponding to the exaggerations of the Herbart-Ziller teaching methods - a logicism which has rightly been rejected by modern educational reformers on grounds of developmental psychology? Getting rid of what is logically unnecessary can perhaps mean that one removes both extra material which arouses interest and "redundant" material which promotes the learning process, i.e. which is superfluous from a logical point of view, but is essential for teaching because it gives the students the necessary repetition and time for familiarization.

Such objections would certainly be valid if the intention had been to restrict the constructor's work to logical analysis and to let this decide the final form of presentation. But this is certainly not the purpose. It is intended instead that the logical analysis should be a first step giving a better understanding of the structure of the subject-matter, so that the constructor of study material is perfectly clear about his "focal stimuli", i.e. what basic concepts and fundamental relationships he should bring forward. This is obviously not the same as saying that the study material should be presented in this way (pared down to logical fundamentals). The method of presentation has to be treated in a second step and is a question of instructional suitability, which is likely to be answered in different ways for different groups of students.

Obviously, additional "interest-arousing" material must often be introduced to increase motivation and for illustrative purposes. Similarly, it is clear that repetitive material must usually be included. But such additional material should be inserted consciously and systematically. Any form of "filling-in"-material which is not in itself focal - should have a clear instructional motivation and not be there by chance or because one has only a hazy notion of what one really wants to achieve. If this degree of rationality and awareness is to be attained, it is frequently necessary to begin by "logical stripping". But of course this does not mean that one stops at this point and adopts mere logical nakedness as an instructional ideal.

We shall return to the question of the educationally and psychologically most suitable form of presentation at several points in our discussions below of how the preliminary version of the study material should be constructed.

In the present section, however, it is possibly worthwhile to stop and consider briefly the more general question: It is possible to make a psychological analysis of the subject-matter in such a way that it will give a better starting-point for choosing instructional procedures; and which methods of analysis will be most fruitful? Unfortunately our psychological knowledge in this field is still scanty, and many problems await deeper study.

In general, we can say that a psychological analysis of a particular subject-matter for teaching purposes will often amount to an analysis of the possible and desirable interactions between a student and the subject-content. In other words, it involves a study of the relationships between the specific subject-content as stimuli and the student's response reactions. If the logical basic unit can in most cases be considered to be the "concept", the psychological unit would normally be the individual stimulus-response connection, i.e. a behavioral unit with its stimulus conditions.

In such an analysis, however, it should not be forgotten that the human learning process is characterised to a high degree by its complexity and by parallel learning on different "levels". To describe the learning process simply in terms of separate S-R connections often implies, therefore, an over-simplification, which is not well suited to guide our decision on teaching strategies.

From the point of view of instruction it may often be worthwhile to observe four different types of learning that go on more or less simultaneously: (a) the learning of separate "subject-matter items", (b) "field articulation" or the learning of "subject-matter systems", (c) the learning of "subject-matter treatment techniques" (study habits, problem solving approaches etc.), and (d) the learning of "subject-matter attitudes".

To make our reasoning clearer and more precise, let us introduce some simple symbols and give some examples:

US = undifferentiated stimulus
FS = focal stimulus
NS = non-focal stimulus
CS = correlative stimulus
PR = pupil´s reaction (response behavior)
$\longrightarrow$ = associative connection (with the general meaning "is followed by", "gives rise to" etc.)
$\dashrightarrow$ = temporal development (from before learning to after learning)

We should then be able to exemplify some common types of learning in the following way:

a. Learning "subject-matter items", I: One-way connection. Here the learning process consists of practising the correct reaction to a given stimulus without reference to its sequence or position in a system.

$$FS_a \longrightarrow PR_a$$

b. Learning "subject-matter items", II: Reversible connection. Here again it is a question of reacting adequately to the correct stimulus. In this case, however, the association can take place in both "directions". What at one moment is the response Z to stimulus A should be able to function, when necessary, as stimulus Z and then result in response A. A typical case of this reversible association, to give a concrete example, is obviously the learning of vocabulary in a foreign language, when a normal requirement is skill in translating both ways. When teaching English to a Swedish child, for example, not only must a Swedish word (sw) be able to produce the English equivalent (eng), but the English word must also produce the Swedish one.

I. e.:

$$FS_{sw\ 1} \longrightarrow \left| \begin{matrix} PR_{eng\ 1} \\ FS_{eng\ 1} \end{matrix} \right| \longrightarrow PR_{sw\ 1}$$

c. Learning "subject-matter items", III: Disconnection of supporting stimuli. Learning often implies a development from a correct response after maximal help to a correct response with a minimum of assistance. Expressed in terms we have used elsewhere, we are here concerned with a gradual withdrawal of "correlative stimuli".

I. e.:

$$\left(\left. \begin{matrix} FS_1 \\ CS_1 \end{matrix} \right\} \longrightarrow PR_1 \right) \dashrightarrow \left(FS_1 \longrightarrow PR_1 \right)$$

It is often, of course, a question of a procedure with several intermediate stages of this general type:

$$\left[\left.\begin{matrix}FS_1\\CS_{1.1}\\CS_{1.2}\\CS_{1.3}\end{matrix}\right\}\rightarrow PR_1\right] \dashrightarrow \left[\left.\begin{matrix}FS_1\\CS_{1.1}\\CS_{1.2}\end{matrix}\right\}\rightarrow PR_1\right] \dashrightarrow \left[\left.\begin{matrix}FS_1\\CS_{1.1}\end{matrix}\right\}\rightarrow PR_1\right] \dashrightarrow \left[FS_1 \rightarrow PR_1\right]$$

d. Learning "subject-matter systems", I: Sequences. A common form of learning, which goes beyond learning one item at a time, is the practice of "chain-connections". In this case we have a series of stimulus-reaction connections, in which the internal order is important, and in which the response in the first stage becomes the stimulus for the next:

I. e.:

$$FS_1 \rightarrow \left|\begin{matrix}PR_1\\FS_2\end{matrix}\right| \rightarrow \left|\begin{matrix}PR_2\\FS_3\end{matrix}\right| \rightarrow PR_3 \text{ .... etc.}$$

e. Learning "subject-matter systems", II: Refined discrimination. Even one-way association implies a certain form of discriminative learning (practising the right reaction to the correct stimulus, when this stimulus must be selected from among a large number of other stimuli which are irrelevant for the response). What we are considering here is something else: a differentiated reaction to separate parts of a larger complex which has previously been experienced as unitary as far as reaction is concerned. In the uncomplicated association, we have a simpler figure-ground relationship, in which a focal stimulus is given a certain content and is brought sharply into focus while other stimuli recede into the background. In this refined discrimination we get an increased differentiation within the focal sphere. We proceed from undifferentiated wholes in focus to differentiated wholes in focus (while retaining experience of the whole).

e.g.:

$$\left[US_8 \longrightarrow PR_8\right] \dashrightarrow \left[\begin{matrix}(FS_{8.1} \longrightarrow PR_{8.1}\\(FS_{8.2} \longrightarrow PR_{8.2}\\(FS_{8.3} \longrightarrow PR_{8.3}\end{matrix}\right]$$

Continued differentiation can naturally also result in the sorting out of some part of the whole as not being relevant:

$$\left[US_9 \longrightarrow PR_9\right] \dashrightarrow \left[\begin{matrix}(FS_{9.1} \longrightarrow PR_{9.1}\\(FS_{9.2} \longrightarrow PR_{9.2}\\NS_{9.3} \longrightarrow PR_0\end{matrix}\right]$$

f. Learning "subject-matter systems", III: Increased generalization. Another type of learning implies the ability to see the connection between phenomena which have previously been experienced as separate. I. e.:

$$\begin{tikzcd} FS_{1.1} \arrow[r] & PR_1 & & FS_{1.1} \arrow[dr] & \\ FS_{1.2} \arrow[r] & PR_2 \arrow[rr, dashed] & & FS_{1.2} \arrow[r] & PR_1 \\ FS_{1.3} \arrow[r] & PR_3 & & FS_{1.3} \arrow[ur] & \end{tikzcd}$$

The above descriptions should be looked upon as exemplifications, and not as an exhaustive survey. In addition to these types of learning, there are of course, as we have already indicated, the learning of the techniques of handling the material (methods of study) and attitudes towards the material, commonly going on simultaneously.

It would be useful in several respects to carry out, at the preliminary stage, analyses of the types considered here, and in doing so the possibility of an empirical study of students' reactions should be borne in mind. An examination of the desired stimulus-reaction connections prevents the importance of some type of connection being overlooked. For example, if it is necessary for the student to be able to behave in terms of reversible connections within a particular area, the training should normally be so designed as to give room for training both "directions". Empirical data indicate also that this is a correct procedure. Usually there is not much transfer from "one-way training" to behavior in the "opposite direction".

It is particularly important not to concentrate so closely upon learning subject-matter items that simultaneous parallel learning processes of other kinds are neglected. It is often the case that learning of items can take place in many ways with greater or lesser efficiency (time taken). But some of these ways demand simultaneous learning of subject-matter systems (e.g. generalization or differentiation), while others do not. Similarly, some learning processes are valuable for the development of individual study techniques, while others can be less valuable from this point of view.

Frequently a method which results in a relatively small increase in effectivity as far as the learning of items is concerned may well at the same time lessen the possibility of learning a good study technique. In subject-matter analysis, therefore, the questions to be considered are not only: What material should be chosen? In what order should it be presented? We must also ask: What type of behavior do we require from the student when he is confronted with the study material? Do we ask him to copy given information, do we let him guess the answers, or do we help him to think out the solution to a problem? If the programmer is constantly aware that he must ask himself this double question ("Which way to the information?" and "Which information?"), he should run less risk of finding himself imprisoned in a one-sided programming routine.

8. CHOOSING MEANS OF PRESENTATION

8. 1. SOME PROBLEMS IN TERMINOLOGY

Like many other terms in the field of educational technology, the word "teaching machine" has caused a great deal of confusion: (a) The term has aroused undeserved negative reactions because in the minds of many it is strongly associated with automation and "soulless" mechanization. (b) It has, in innumerable discussions, been difficult to distinguish between "teaching machine" with its special meaning for the programmer and the teaching machines of other types which have already been in existence, such as presentation aids in the audio-visual field. (c) It has sometimes been difficult to define a clear and definite boundary between "teaching machines" and program presentations in book format. In some contexts, consequently, the programmed textbook has been presented as one type of "teaching machine".

The first-mentioned point, a, is perhaps of least importance in principle, although at the present moment it does have a certain bearing on our communication to teachers and other groups. We can be fairly safe in assuming that mechanical aids of different types will gradually become so much a part of our surroundings (and hopefully so well adapted to human needs) that they will lose their "threat" image. The two other points, b and c, concern, on the other hand, tangible conceptual obscurities which it would be advantageous to have cleared up. In this presentation we do not want to give definitive suggestions for general use. But when we, within the frame of our present discussions, wish to achieve a fair degree of precision, we shall use the following terms with the meanings set our below:

The term "presenter" is used for arrangements whose main function is to present to the student a certain pre-arranged stimulus-sequence. Certain presenters have tangible mechanical components (ex. wheels and/or levers). To this group belong projectors for lesson material on film strips, tape recorders for lesson material on soundtapes, TV sets for TV lessons, etc. Several so-called "audio-visual aids" can be considered mechanical presenters when used as they ordinarily are at the present time. Presenters of a non-mechanical type have long been in use in teaching. Large pictures and maps (for group demonstrations) and textbooks (for individual use) can ordinarily be counted as belonging to that category.

The term "reactor" is used for those arrangements whose main function is to offer the student the opportunity of making a response reaction. The "question book" in the form of practice tests or work sheets illustrates a non-mechanical system. We find the mechanical type in various so-called "feedback systems"(or "teletest systems") which include student sets for response reactions (press-a-button type) (making possible individual and group combined "reaction totals"). Simpler forms (which do not offer the possibility of getting individual reaction totals) are also available.

Of principal importance for the auto-instructional system is, however, that the question is not one of presentation only or of reaction alone, but of a constantly alternating sequence of presentations and reactions. An arrangement or system, mechanical or non-mechanical, the purpose of which is to offer the student programmed teaching with such an alternating sequence, could be described by the general term "integrator". If the arrangement in question is built up of mechanical parts, then we are correct in referring to it as a "teaching machine". If it does not have any mechanical parts at all, it will suffice in many cases to speak of a "programmed workbook". If we wish to avoid entirely the term "teaching machine", and if we in any case want more specific terms and are not afraid to coin new words, then we might use the term "tutcior" as a general name for an arrangement based on programming and facilitating systematic alternations between presentations and reactions (=integrator) and use the terms "tutomat" for mechanical arrangements and "tutoprint" for the non-mechanical. See Figure 8. 1 for an outline of our terminological suggestions.

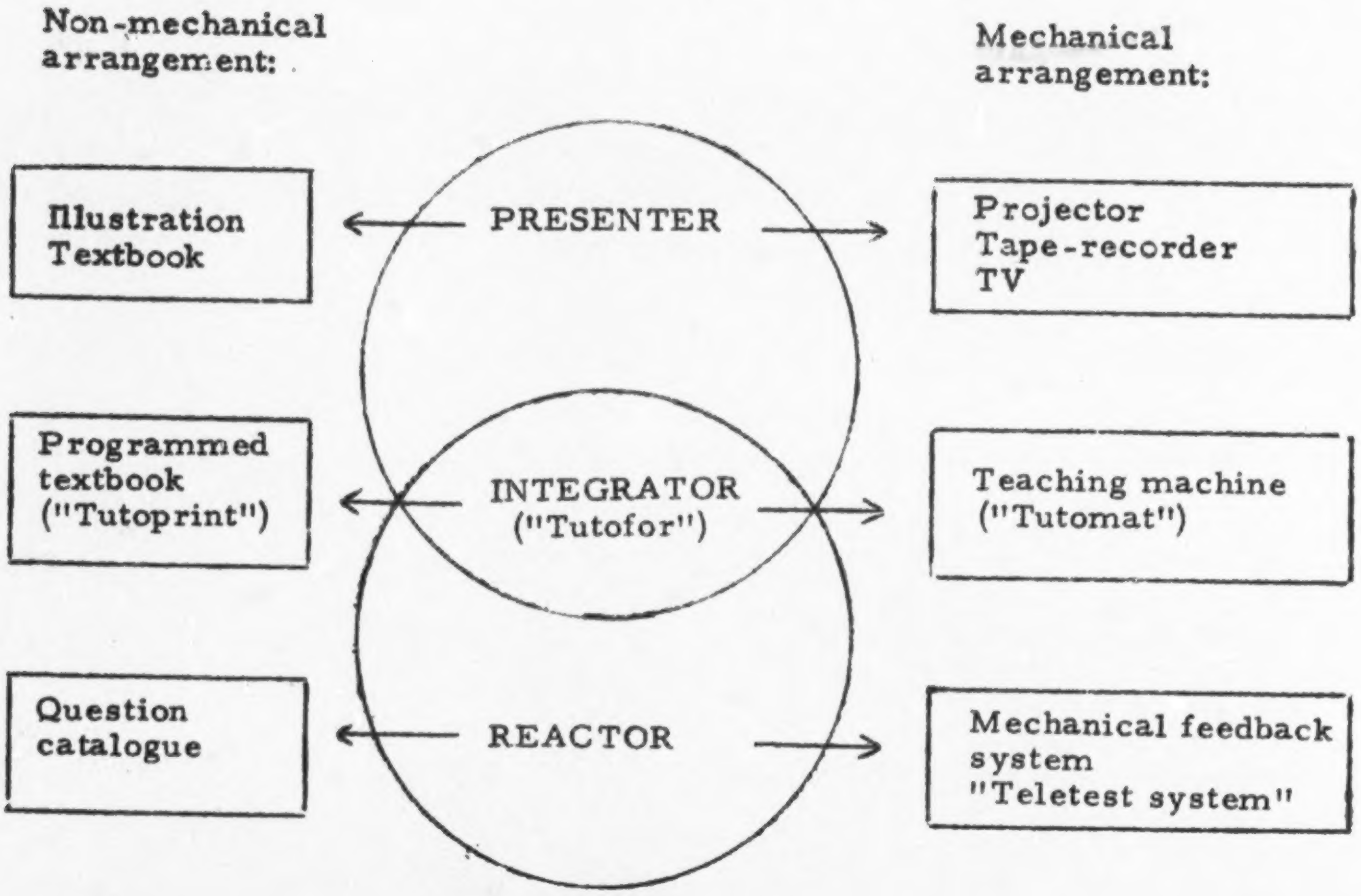
Non-mechanical arrangement:
Mechanical arrangement:
Illustration
Textbook
PRESENTER
Projector
Tape-recorder
TV
Programmed textbook ("Tutoprint")
INTEGRATOR ("Tutofor")
Teaching machine ("Tutomat")
Question catalogue
REACTOR
Mechanical feedback system
"Teletest system"

Figure 8. 1 Diagram of relationships between some of the main types of teaching aids

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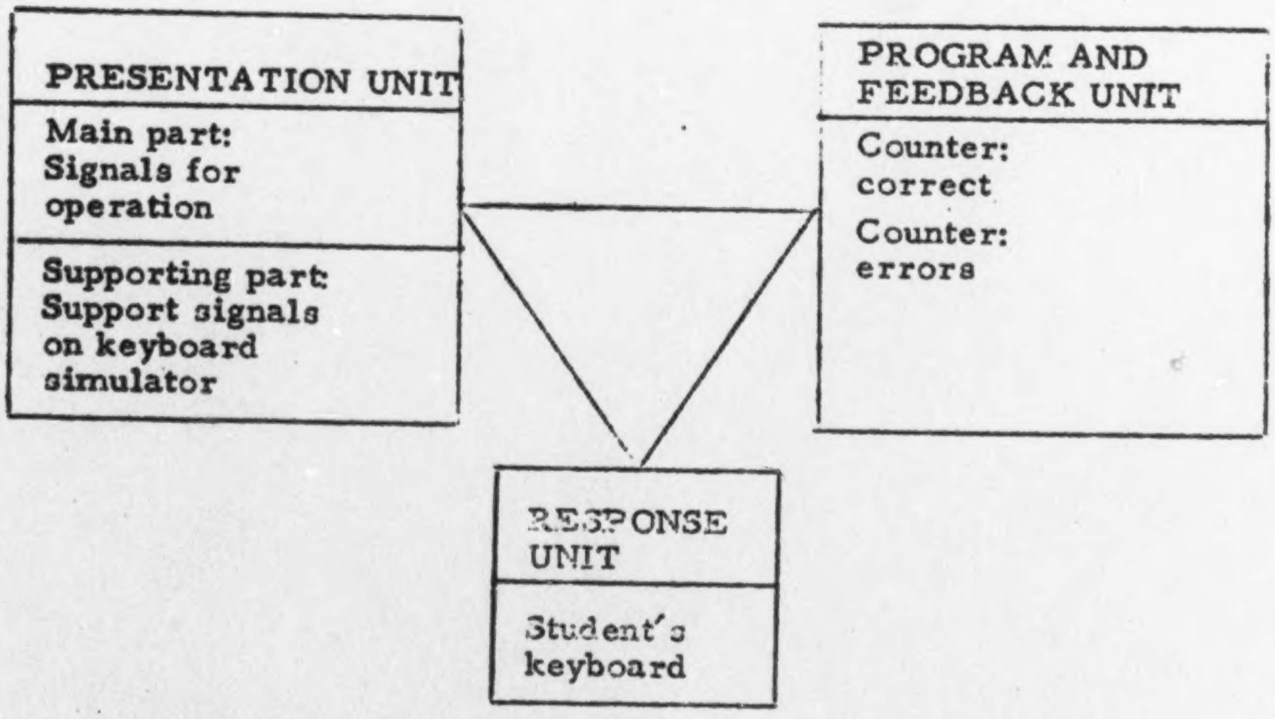

PRESENTATION UNIT
Main part:
Signals for operation
Supporting part:
Support signals on keyboard simulator
PROGRAM AND FEEDBACK UNIT
Counter:
correct
Counter:
errors
RESPONSE UNIT
Student's keyboard

Figure 8. 2 The principal components of a SAKI-type system (Further explanations in text)

8.2 CHOOSING BETWEEN MECHANICAL AND NON-MECHANICAL ARRANGEMENTS

The author of auto-instructional course material must decide in the preparatory phase the form which he intends to use in offering the program to the student, since different forms of presentation require to some extent different patterns in detail work. It is, of course, desirable that the choice of the form of presentation be based on data from the current goal analyses and the student analyses, and that the actual technical aid situation aid situation at the time is not taken into consideration until the final round. In order to make a judicious choice, the person who has this responsibility must kepp up-to-date with the rapid developments in the field of teaching aids and must try to choose critically from the announcements of the hawkers in that particular market,who are more often than not considerably louder than they are informative.

What, in principle, are the advantages which mechanical program presentation has to offer? In which respects can it increase effectivity in the auto-instructional context?

Obviously the debate for and against mechanical teaching systems has often raged with more intensity than objectivity. At one extreme are those who believe that programmed teaching cannot function without mechanical help. In this group we find - besides some manufacturers of machines - principally those who lay great stress on the machine's function as a discourager of cheating. At the other end of the continuum are those who claim that mechanical aids are an entirely superfluous "frill". In this group we have most likely a considerable number who react negatively and emotionally to instructional innovations in general and to instructional apparatus in particular. In this group can be found persons who quite simply find it "inhuman" and "soulless" to place a student in front of a teaching machine (but who seldom call constant use of sarcastic criticism from a teacher "inhuman" and seldom or never consider it "soulless" or meaningless to force students who have already mastered certain material to listen to the teacher's repetition of it for the benefit of those in the group who are not so advanced).

But this resistance group to machine teaching also includes more reasonable critics. They are above all anxious that which is good in the basic principles of programming and which often can be put into effect in a well-planned and adequately tested workbook should not be lost in misplaced enthusiasm for the surface glamour of the impressive machines with all the pushbuttons (which can, of course, easily be shown off to admiring and not so well-informed visitors, thus giving the organization or school an easily earned reputation for keeping up with the times). Through the industrious use of such expressions as "complicated page-turners" (for branching machines) and "hard plastic book-covers" (for linear machines) and by means of the somewhat tiresome but helpful refrain that "it is the program that is most important", a number of these critics have contributed to a more realistic view of mechanical arrangements. They have brought teaching machines back down to earth again and have prevented the myth of the "emperor's new clothes" from spreading in too wide circles.

The most reasonable attitude at the moment seems to be that many types of existing programs should function very well for many student groups without any mechanical components at all - and this has also been demonstrated by repeated empirical tests. This does not mean, however, that mechanical aids for other types of programs and other groups of students cannot increase effectivity and even be essential for certain types of programs. Those participating in these discussions have too seldom taken into consideration the great differences in the terminal situation, both as to type of stimuli and type of reaction.

For example, it is quite obvious that a self-instructional program in a foreign language could not be made very effective if only visual presentation of word pictures and objects as well as written answers were used. Here the auditive stimuli as well as the auditive-oral interaction between the tape-recorder unit and the student are a fairly obvious mechanical supplement.

Mechanical components are often just as natural and as essential when the terminal reactions are of a manual-motor type. We can no more renounce mechanical components in teaching manual proficiency in an auto-instructional teaching situation than we can in an ordinary teacher-instructional situation. For instance, we do not train a typist without a typewriter or a punching-machine operator without a practice punching-machine.

One of the best known "student-adapted" types of teaching machine is "SAKI" (constructed by Gordon Pask; cf Lewis & Pask, 1965, and Figure 8.2). "SAKI" was designed for learning different types of keyboards. The special keyboard on which the student is going to practise is connected to the system which, in addition, has a presentation unit and a program-and-registering unit. If the student is to practise card punching, then a punch-card keyboard is plugged in to the circuit. The presentation unit has two parts: the upper with rows of numerals in sequence and the lower with numbers arranged as they are on the keyboard. The student presses down on his keyboard ("response unit" in the figure) that key which has the same marking as the light signal which flashes on the upper part of the presentation unit. As an extra aid for the student in identifying the right key, an extra light signal is given in the beginning in the lower part of the presentation unit (from which, of course, the position of the key is easily seen). When the student has pressed the key both lights go out and a new pair of stimuli is offered. The number of correct and incorrect reactions are registered, and can be seen on the feedback unit. The tasks increase successively in difficulty as the student gains in assurance and speed, partly through faster presentation, partly by successive fading, and finally complete disconnection of the lower part of the presentation arrangement. (It has been demonstrated that this set-up can produce good results in teaching without an instructor, although not necessarily better than the results attained with a combination of instructor plus practice punch; Randell, 1963.)

The manual training situation can also in an indirect way lead to the decision that it is desirable to use some sort of mechanical presentation. Many manual practice situations are such that the student's hands and eyes are busy performing a certain task (for example, that of putting together parts of the machine). It would be both impractical and ineffective to present simultaneously to the student repeated visual instructions in a programmed workbook. He would be forced to shift his visual attention unceasingly back and forth betwen the page of the book and his work. In a situation of this kind it is natural that the programmed instructions are given auditively through a recorder, possibly with appliances which could prevent disturbance of others (earphones), but which still do not interfere with the mobility of the student (wireless transmission).

For the teaching of many kinds of skills, "simulators" of quite a complicated type are used (perhaps best known in pilat and driver training). Ordinarily these provide a versatile imitation of natural situations, including also representative stimuli as well as the usual reaction possibilities (with the exception of some of the expense and the danger of the real situation). The student is trained, when he receives certain stimuli (e.g. picture of moment of danger on the road), to react in a certain manner (e.g. with special maneuvers with levers). Usually teaching in simulators is carried out by individual instructors. It should in many cases be possible, however, to rationalize the procedure by successive machine-presented instructions. If, moreover, the mechanically-offered stimuli sequence is built according to plan from a simpler to a more complicated course, and with some degree of adaptation to the student's speed of progress, we have a typical example of a programmed teaching situation in which the mechanical components play a natural role.

In all of the examples now given, the introduction of the mechanical factors depends upon the presence of essential stimuli and/or essential types of response in the terminal situation, which cannot be translated naturally or with maximum effectivity into written-verbal or static picture symbols alone. There is a tendency to forget that terminal situations of this type play an important part in ordinary school teaching (e.g. in teaching languages) and that it is most significant in many adult education programs (in industry, for example). Once attention has been directed to the existence of these special situations, however, it is usually quite clear that mechanical arrangements often are of basic importance here.

Using the machine to discourage "cheating" is another story. Many of the machines presented during the early sixties had that more or less as their only purpose. The usual technique here is, as we know, that the machine presents one task at a time (via a "task-window", for example). When the student has answered it (possibly by writing in an answer blank), he draws forth, by some means, a key answer so that he can compare his answer with the "pattern answer". On many types of machines it is impossible for the student to change his own answer afterwards or to see the key answer before. The feeding mechanism of the machine moves in one direction only, and the student's own answer glides in under a transparent cover as soon as the model answer is turned forward.

Are these special anti-cheating functions sufficient reason for acquiring these simple, but often fairly expensive machines? Is it not a mistake to introduce the thought of cheating during the learning process? (When it is not a question of a final examination, a look at the key answer can sometimes be both sensible and practical, and above all, it is both sensible and practical to be able to look over material which has already been done.) Is it not simply a case or provoking a less desirable attitude to the work if this is always presented in "cheat-proof" form (which might in some cases lead to an attempt to "fool" the machine)? These questions are meant to be thought-provoking; it is difficult to give them a definite answer valid for all kinds of situation.

It might be well to point out, however, that the role of the machine in this connection cannot always be completely covered by the possibly somewhat misleading term "anti-cheater". Actually that term ordinarily covers three different functions: (a) The student is prevented from seeing the key answer before he tries to reply himself. (This is, of course, the most typical of the "anti-cheating" functions.) (b) The machine guarantees that the carefully planned work sequence is followed by the student, who does not have the opportunity of taking any undesirable short cuts or zigzagging through the material (this could be called the "sequence-guarantee" of the machine). (c) The machine limits the number of distracting stimuli and facilitates, thereby, the focusing of attention on the focal stimuli in each stage - unlike, for example, the welter of intertwining items of information to be found on one page of an ordinary book (this could be called the "focusing" function of the machine).

It is easy to speak disparagingly of "page-turning" machines, but it is not impossible that these three simple functions in certain cases can have a not insignificant influence on furthering effectivity. At the beginning of this century - long before teaching machines in the modern sense had even been thought of - Thorndike, one of the leading figures in the study of the psychology of learning, mentioned how advantageous it would be for learning if textbooks could be so constructed that they did not allow the reader to proceed to page 2 before he had completed all that he was supposed to do on page 1 (Thorndike, 1912). Obviously it is just something of that uncompromising stage-by-stage presentation and stage-by-stage control which the program tries to achieve and which the simple machines, moreoever, try to guarantee.

Let us consider a typical correspondence course taken by a student during the vacation period. The course offers informative material and a long list of practice problems in a "letter" which the student is supposed to read through before answering the test items. A conscientious student reads the letter carefully and solves the problems scrupulously in the prescribed order. A less conscientious student does not read so carefully, skips some of the problems which seem to be difficult, or takes a peek at the key in order to get through them as soon as possible. A capable student feels, perhaps, that he can take considerable short cuts, and sometimes goes directly from the information in the letter to the final assignments. In some cases, naturally, this skipping technique on the part of the student can do no harm, especially since current correspondence courses are not often designed for the individual and therefore can contain entirely unnecessary repetition material for certain groups of students. But in many cases, this "short-cut behavior" (whether it derives from a desire to get through as quickly as possible or quite simply from the student's overrating of his own knowledge and ability) leads to a less satisfactory end result.

Some form of "sequence guarantee" should logically reduce to some extent the danger of a deterioration in final results. And if such a sequence guarantee can be desirable even in an ordinary textbook or a correspondence course, it is reasonable to suppose that a guarantee would be of even greater importance in a programmed course where the order of assignments and number of assignments are the result of careful preliminary planning and testing, and where, therefore, "skipping behavior" is more seldom motivated. - There is obviously good reason for further testing of programs both with and without various simple "sequence-guaranteeing" devices. We can only hope that later on we will be able to make a more definite statement about the value of these two modes of procedure. So far, much empirical research seems to have ended up by not being able to demonstrate significant differences between machine and text versions. (The "anti-cheating" component is - regardless of what one thinks of its importance for instructional effectivity - of special value in connection with research, since it facilitates interpretation of the student's running performance; the student cannot, for example, complicate the work protocol with later changes.)

If we sum up what has just been discussed and add to this some other points of view often expressed, we have the following list of common arguments for mechanical set-ups:

1. When the instruction material, in order to achieve full effectivity, must contain stimuli of another type than the printed word and the static picture (for example, moving pictures or auditive stimuli), then mechanical components are usually needed. A special case, which we will deal with in more detail below, is when we need to amplify or modify the observation area.

2. When the instruction situation, in order to achieve full effectivity, must give the student other reaction possibilities than those offered by pen and paper (such as is the case when training many manual-motor skills), the mechanical components are usually equally necessary. (This can sometimes mean construction of special teaching apparatus such as SAKI, while in other cases it may mean only the use of a programmed workbook in combination with an ordinary working machine.)

3. The instruction material in a typical auto-instructional course is designed to be presented step-by-step, unit-by-unit, in a sequence carefully planned and fixed in advance, with the key solutions immediately following the student's own response attempt. The machine can be a guarantee that this planned, step-by-step and well-focused presentation can be realized, so that the student does not take forbidden short-cuts, skip tasks or look at the key answers before he has written down his answer.

4. When more complicated systems of individualization are desired, a mechanical presentation can sometimes simplify the alterations needed within the total bank of instructional units and thus save time.

5. When it is desirable to obtain "reaction summations" quickly as an indication of the student achievements, mechanical devices for the registration of correct and incorrect answers can save a certain amount of work.

6. In some cases machines probably increase motivation among certain students for whom the physical manipulation and the gambling-type set-up may create an atmosphere of fun and play.

When it is a question a choice between the tutomat arrangement and the tutoprint arrangement, arguments 1-3 should be the decisive ones, while arguments 4-6 are usually of secondary importance. If a detailed student-adaptation is desired (argument 4), mechanical aids are sometimes desirable and can - as a number of experiments have demonstrated - be brought about by systems including a computer. For reasons of economy, among others, these arrangements so far have mostly occurred in research situations. In this case, however, it is reasonable to expect innovations and quick changes (cf. Box 8.1).

Box 8.1 Some notes on computer-assisted instruction

A computer may sometimes be given the role of a teaching machine. We then talk about computer-assisted or computer-directed instruction. In some general discussions the two concepts of "programmed instruction" and "computer assisted instruction" have sometimes wrongly been considered to be in opposition to each other or to deal with widely different strategies. Often it would be more correct to consider computer-assisted instruction as a special case of programmed instruction: a case where one for one reason or an other has found it convenient to have the computer take over information storage, answer comparisons, and feedback to the student. The computer is better than more conventional teaching machines mainly in two respects: (a) It can store large data collections and thus hold both detailed student profiles and several different courses at the same time. (b) It can handle a great number of analyses and "decisions" more easily and more quickly than other arrangements.

Let us take a look at the "conversation" between computer and student during a logic game in which the task of the student is to identify a letter the computer is "thinking of", using as few questions as possible. The student is allowed only to put one question at the time, and the questions may deal with the number of curves, loose ends, obliques etc. (For instance, the letter X has no curves, but four loose ends, whereas R has one curve and two loose ends.) This is how a conversation may proceed:

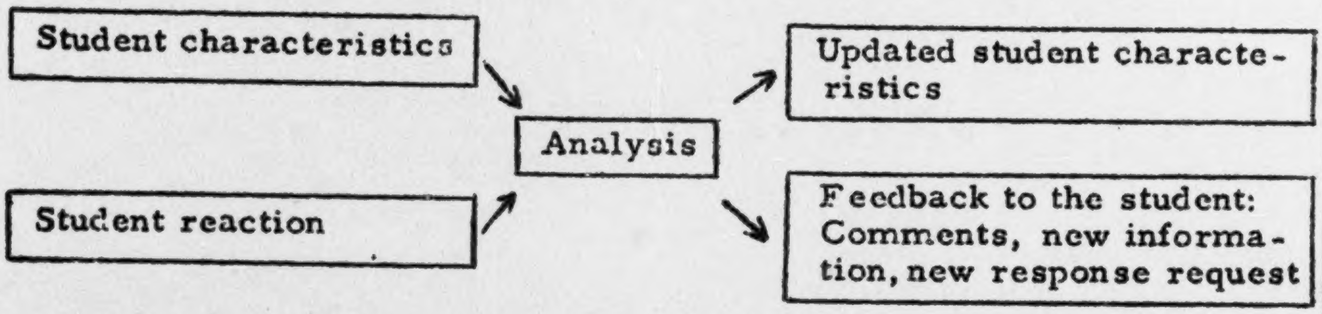
Computer: Start
Student: Curves?
C: One.
S: Loose ends?
C: Two.
S: Obliques?
C: Zero.
S: C. (Meaning C is the correct answer.)
C: You don't have enough information yet to get the right answer. How do you know it isn't J, for example?
(Note: The computer will not accept a guess from the student, if he does not have enough information to back up a final decision; this is not a guessing game, but a logic game.)
S: J.
C: You don't have enough information yet. How do you know it isn't C, for example?

Box 8. 1 (continued)

S: Horizontals?
C: Zero. That was a wasted question. It did not eliminate any possibilities.
S: Verticals?
C: Zero. Good question.
S: G.
C: Wrong. Your guess is not consistent with the information you have been given. You must have forgotten that the right letter hasn't any horizontal lines. The letter you guessed can't be right - it has too many loose ends.
S: Curves?
C: The answer is still: one.
S: C.
C: Yes, you have done it. Good work. If you want to play again, start right in.

The example shows how the storage capacity and ability for quick analysis of the computer can be utilized to demonstrate to the student when he is asking an unnecessary question or comes up with c conclusion not consistent with information given. This high degree of individualization is quickly felt by the student to be both effective and exciting.

In principle the instruction of the computer follows this design:


Student characteristics
Student reaction
Analysis
Updated student characteristics
Feedback to the student: Comments, new information, new response request

The difficulties involved here are most often neither technical, nor economical, but educational-methodological. Technical solutions are available, and the costs need not necessarily be forbidding (if many students can utilize the equipment; also it seems reasonable to predict diminishing costs in the future as a consequence of the development of electronics). But the construction of the highly individualized program involves difficulties of a kind that teachers and education experts so far have only to a very limited extent dealt with systematically.

Box 8. 1 (continued)

It is not at all self-evident what kinds of feedback are educationally most fruitful for various combinations of student characteristics and student reaction. Today, therefore, the problem is not so much what the computer is able to do, but to what extent we as behavioral scientists have sufficient knowledge of complex human learning to compose effective instructions for the computer.
(The example above of logic games is based on Swets & Feurweg, 1965.)

8. 3 VARIOUS MECHANICAL ARRANGEMENTS

When there is a question of choice between different types of tutomat arrangements, a number of other factors must be taken into consideration. In several cases (especially where special manual skills are concerned) a "special tutomat" must be constructed for that particular purpose. Pask's "SAKI" for card-punching is an example of this. Simulator-arrangements with programmed instructions provide other examples. In many cases, however, a more generally applicable arrangement can be considered. Most of the so-called teaching machines on the market seem to be "general tutomats" in this sense of the word, and are chiefly suitable for advancing verbally communicable knowledge and skills.

Examples of the factors to be taken into consideration in choosing among the machines for more general use now on the market are presented below. (Points 1-4 deal chiefly with the stimulus phase, points 5-7 with the reaction phase, and points 8-10 with certain forms for interplay of reactions and stimuli. Points 11-12, finally, contain some practical-economic considerations).

1. Is visual presentation sufficient (as many of the constructors of apparatus seem to assume) or is auditive presentation also necessary? Auditive presentation is obviously of importance if the terminal behavior demands auditive discrimination, or if the focusing of the behavior is substantially facilitated by auditively communicated instructions (compare our example above); this is also quite obviously true in the case of students who can neither read nor write.

Auidtive presentation is technically not especially difficult to arrange and occurs in many tutomat systems. But since it often involves a substantial increase in the cost of materials. it should not be used unless necessary. In certain cases (ex. in the versatilely useful "MTA Scholar") the auditive unit is separate so that visual presentation only can be used at first, and the auditive unit brought into use later on if the need for it becomes apparent.

2. Is it most advantageous in the teaching situation under consideration to choose the printed page or projected still pictures as a means of presenting information? Those apparatus which use printed sheets are often cheaper. Moreoever, the printed sheet is, as a rule, easier to produce within the frame of existing resources, for example in a school (where ordinarily you are more likely to have access to a stencil apparatus than to a developing laboratory). On the other hand, a supply of paper programs often demands a great deal of storage space. In addition, paper

programs, if they are to contain illustrations (especially color photos), can be considerably more expensive than programs on microfilm. If the projection apparatus is chosen, care must be taken that the projected pictures do not create special "tiring" effects.

3. Is "focusing" on one task at a tine essential to the program?

4. Is it desirable to be able to try out stenciled versions of new programs directly without encountering problems with paper format or type of paper? If so, machines using odd sizes of paper are less suitable, as well as apparatus which work with different types of running paper, lengths (folded fanwise or rolled).

5. Is it essential to have self-constructed answers (with reference to the special terminal behavior which one hopes to achieve), or is it sufficient (perhaps even more natural) to work with choice reactions? Machines which work with written student answers are best suited to the former, whereas most machines which work with keyboard responses are better for the latter. It should be noted, however, that certain keyboard machines can be used for self-constructed answers (using combinations of letters or of numerals).

6. Is it desirable that the student be able to work on a special "answer strip" to make possible repeated use of the same program sheet? If so, apparatus without separate answer arrangements are not suitable. Is it desirable to be able to use the machine both with and without a special answer strip? (In research one may want the answers included in the program, while for practical use it is perhaps desirable to save paper.) If this is the case, then apparatus with both possibilities are worth considering.

7. If some form of error summation is desired, it is usually necessary to use some kind of key-board apparatus (these often have error computers, e.g. "Auto-Tutor Mark II"). There are also machines with written answers and some "semi-automatic" error-counting operated by the student. In the latter case, however, one must be sure that the student does not "forget", either wittingly or unwittingly, to mark all errors.

8. Is it enough to work with linear progression, that is, the same system of instructional units for all students, or is it desirable to have possibilities for "branching" within the unit sequence? Most tutomats are designed for linear progression. There are a few, however, which offer good branching possibilites; among the best-known of these is "Auto-Tutor Mark II". (The principal questions in regard to various

branching-off procedures will be discussed below.)

9. Is there a need for a mechanical "skimming"-device as a time-saver in later repetition? Very few apparatus have any such possibility. In principle, an arrangement of this type can be built into a tape recorder unit. The student thereby enters a high frequency tone on the tape every time he makes a mistake. When the tape is run back quickly afterwards, it slows down to normal speed just at those points.

10. Is there any need for a mechanical pace-accelerator? It is usually considered one of the advantages of programmed instruction that the student may set his own pace. In certain cases, however, successively increased demands - still fitted to the individual - can be even more advantageous, since they may force faster performance. The Pask-machine "SAKI" described above suggests how an arrangement of this type can be worked out. Ordinarily these arrangements are expensive, however, and it is not at all certain that their instructional value is in proportion to the cost.

11. Which is more important, low cost or durability? Many variations are available, from the cheap and disposable paper devices to expensive and fairly durable metal constructions. Unfortunately, many of the existing apparatus are both expensive and easily damaged.

12. Which is more important, capacity for program storage or space saving (and possibilities for stacking)? The well-known problem of the good lady's shoe - it must be large inside and small outside - has turned up again in a new version. The supply of machines for one class should not take up too much space. On the other hand, they should not hold so little continuous material that they must constantly be opened (by the teacher, for instance) in order to change the material. Naturally, the storage capacity in principle is greatest in those apparatus which use micro-material for projection. Because of the space needed for the projector itself and the power supply, however, these apparatus can seldom be listed among those most easily handled.

8.4 AMPLIFYING AND MODIFYING THE OBSERVATION AREA: SOME NOTES ON CCTV AND VIDEO-RECORDING IN INSTRUCTIONAL SYSTEMS

Among the training situations for which some sort of mechanical arrangement seems indicated, we mentioned above the special case where there is a need to amplify and/or modify the "observation area". Good techniques for doing this are now available in the form of closed-circuit television systems and vide-recording. Since such systems are now increasingly being used as major components of instructional systems, it seems pertinent to make a brief digression here from our main theme with some notes on these aids. We shall focus on some general principles, illustrating various way of amplifying and modifying the observation area, but we shall also try to make our comments concrete by relating to a particular area of application.

8.4.1 General Character of CCTV and Video-Recording

Before we try to answer our main question here, namely how closed-circuit television can be used to amplify and modify the observation area in a way that will be helpful to instruction, it would perhaps be as well to recapitulate briefly some main characteristics of these aids.

"Closed-circuit television"(CCTV) commonly means the transmission of sound and pictures to receivers within a closed system, e.g. by means of cables (as opposed to the open "broadcast television"). Thus a CCTV system is usually clearly defined in its scope, which does not, however, necessarily mean that it is small. It can be a very small class-room system (where camera and receiver are both in the same room for demonstration purposes, sometimes called "desk TV"), but it can also be a system which embraces a very wide geographical area.

A minimum installation for transmission from one room to another has these characteristics: For picture transmission there is a TV camera in the sending area which is connected to a TV receiver in the viewing area and for sound transmission a microphone and loudspeaker respectively.

There is, however, comparatively limited use for such a simple system. Instead, one usually considers a larger installation of the general type outlined in Figure 8.3. (It should be emphasized that the figure gives only a general sketch and not a complete technical diagram.) In the sending area (S) - for instance, a classroom - there are two or three cameras, of which at least one can be worked by remote control, both optically and for direction, and a number of microphones, one of them perhaps a neck microphone for the teacher. Picture and sound impulses go first into the control room (C), where they can be both recorded by means of the video-tape recorder and also transmitted further either completely or partly to one or more viewing areas (V_1, V_2 etc.).

In the control room there is a picture receiver for each camera (monitor). In certain cases pictures from each camera are transmitted, so that there is one receiver for each picture in the viewing room. In other cases, the pictures are selected in the control room, and only one picture is transmitted to the viewers, i.e. the one which seems most valuable at a given moment. If the viewing space is large, it can be equipped with a large number of receivers so that the viewers can form small groups for unhindered observation. But there is also the alternative possibility of using a special projector which shows an enlarged picture.

Within the framework of a system of this kind there are many possibilities for variation. The cameras can be fixed without operators, operated manually within the sending area, or manipulated by remote control. The microphones can be fixed, worked by remote control, or portable. The portable ones can be wired to the control room or be of the wire-less type etc.

The video-tape recorder included in our figure is not, of course, a necessary ingredient. However, as we shall see, video-tape recorders are a very valuable addition to the arsenal of aids whose further development should be followed with great interest by those engaged in the construction of training systems.

8.4.2 CCTV and Video-Recording as "Observation Amplifiers"

Numerous advances in science, education and production are the result of man's success in constructing new aids which have increased his capacity to receive information or process it, or both. The microscope is an example of an aid which has increased man's capacity to collect information, while a computer is a machine which has increased his ability to process it. Without making general comparisons, it would be useful to regard CCTV and video-tape recording as "observation-amplifying" aids of potential value for education in general. Let us, however, for the purpose of illustration, focus upon a special area of application and ask ourselves: Which types of observation-amplifying arrangements, using these aids, are most adequate for use in teacher training: Figure 8. 4 gives some main examples, which I will here briefly explain and comment on.

By "micro-showing" (Figure 8. 4, a) we mean here the possibility of demonstrating small objects and events to a large group of observers simultaneously. This is perhaps one of the most frequent uses of television in education, e. g. in medicine. A dental or heart operation can be followed in detail by a large group of dental or medical students via the TV screen. A demonstration which would otherwise be limited to a very small group of direct observers can now be observed by a very large group. This means that the events which the individual student would perhaps never have the opportunity of seeing because of their comparatively low frequency in the training or practice institution in question can be illustrated concretely in the course of teaching.

Several of the difficulties experienced in teacher training could well be minimized if wider use were made of the micro-schowing qualities of CCTV and video-tape recording. The possibility of giving a concrete demonstration of events within the framework of theory teaching is considerably increased, which should contribute to narrowing the gap between the worlds of theory and practice. Similarly the possibility of the student teacher's seeing and hearing details during the course of an observation lesson is also increased. The possibility of spreading information about infrequent phenomena to large groups is obvious. For this purpose we can use very simple arrangements of the "desk TV" type, by which a theory lecturer can demonstrate an individual child's work with self-instructional material or with a test (in this case the child is present in the lecture room). But it can also be used for demonstrations of test and study material from a studio or classroom (where, for example, a child and a tester or a child and teacher can work undisturbed by the presence of an observation group) or for the showing of a previously recorded demonstration. In this way the methods used in a laterality test, individual pronunciation training or in working with small groups can advantageously be demonstrated. Finally, it could be used for something more like the normal observation lesson, where the student teachers can follow a whole class at work, while a manually or remote control operated camera can take close-ups of interesting details in the course of the teaching.

"Macro-showing" (Figure 8. 4, b) means that an observer can watch several separate observation areas. Signals from different sending areas are led into a common viewing area (with several TV receivers). We find this method used in supervision of traffic areas, prisons and factories; a single supervisor can by this means keep his eye on a large area without leaving his post. A comparable method can be used in teacher training for simultaneous or almost simultaneous observation of several different classes in which, for example, the same step in a given subject is being handled in different ways. Here it is not usually the case that one observer sees many observation objects, but instead that a group of observers, gathered in one place for tutorial discussion before and after the observation, can see picture material from two or more classrooms at the same time. Sound signals from the different classrooms can be switched on alternately to avoid disturbing the observer too much (alternating rather than completely simultaneous observation). Such observations should in many cases give a good background for evaluative and comparative discussion.

"Shielded showing" (Figure 8. 4, c) means that the viewer and the object are shielded from each other. One of the most obvious examples of this type of use is in atomic laboratories. Processes which would be highly dangerous for an observer to study in situ because of radioactive radiation can be studied at a suitable distance or behind protective lead walls. Only the TV camera is in the actual location. In teacher training it is not of course necessary to protect the observer from the observed object. On the other hand, there is an obvious need to protect those observed (the children and their teacher) from disturbance by the observing group. It is true that classes under observation do become relatively easily accustomed by experience to having a small group of observers in a corner of the classroom. But - and this is a particularly important reservation - oral commentaries (by e. g. a teacher of method or education) during the course of the observation are out of the question. Furthermore, an observation group inside a classroom must always be small, whereas a group of observers can be of almost any size if shielded viewing is used. These two factors combined (the possibility of simultaneous commentary and of increasing the size of the group of observers) obviously mean a considerable improvement in the observation situation and can theoretically help to avoid several of the many difficulties in observing lessons. It will be possible to make the observation more meaningful by carefully directing the observers' attention during the observation. All will obtain the same background of experience, which will also make it possible for the teacher of theory to give more detailed and adequate comments afterwards. A large group of student teachers can more easily be given the opportunity of observing even the less frequent phenomena. Administrative and schedule-making difficulties are reduced and teacher students waste less time in travelling.

Another method of facilitating observation by student teachers is to direct their attention by means of a selection of pictures to what the lecturer in education or method considers most interesting at a particular moment ("focused showing": Figure 8.4, d). Technically, this works mainly in two ways: a roving camera is directed at the desired point of interest at the given moment, or a choice can be made in the control room between several incoming pictures (which are continually being studied in the monitors) of what is most profitable to distribute to the viewing room. This procedure has the instructional and psychological advantage that the confusing mass of possibilities for observation are cut down, what is considered important is brought to the foreground, and the rest which from the point of view of informational psychology can at that moment be considered as irrelevant "noise", is cut out. If the choice is made skilfully (and this naturally makes great demands on the person selecting the pictures), this kind of technical device might considerably increase the educational effect of the observation period.

With the aid of the video-recorder, this spatial selection can be supplemented by selection in time. "Concentrated showing" (Figure 8.4, e) means that the raw material is cut and only certain essential points are shown. There are plenty of examples of this type of "reduced" sending in the conventional TV programs on sports or parliamentary discussions. Every football kick and every word said by a member of Congress are certainly not pearls, and skilful selection saves a great deal of time while still giving sufficient information. The same thing can be done with classroom observation material. Student teachers sometimes experience an observation period as somewhat unproductive "sitting-in" partly because they are unaccustomed to observation and it is not possible to direct their attention, but partly also because a certain amount of what happens is naturally comparatively uninteresting, at least as far as the specific point being studied is concerned. A solution to this problem can be obtained by means of the video-tape recorder. Technically this can be arranged either by making a partial recording or by making a selection later (e.g. by partial copying from another tape). The latter method allows a better planned selection to be made; the former, on the other hand, saves time and tape. What we get is a rationalized demonstration situation in which, in addition, we are not bound by time and space. To take one of many examples, there is nothing to prevent our using the material for evening refresher courses for teachers.

Once the observation material has been recorded on video-tape, there is moreover scarcely any limit to what can be done by editing. It would often be an advantage to produce a demonstration tape in which short illustrations of procedures are shown for comparative analysis (different ways of beginning a lesson, different ways of handling a breach of discipline, different ways of concretising abstract conceptions etc. etc.). Such "contrast-illustrating demonstration tapes" should obviously provide excellent starting points for tutorial discussion on many topics. By inserting a preparatory and/or subsequent commentary by the lecturer in method or education, the illustration tape can be built up into independent teaching material which can also be used by a less experienced group leader ("commentary-interfoliated demonstration tape"). An even more important possibility is perhaps that of inserting tasks for the observers. The possibility of stopping a lesson in mid-action to make it possible for the student teachers to consider and make their own decisions about a teacher's possible behavior when faced with concrete classroom incidents and then see what the teacher actually did and what the results were has sometimes been described as wishful thinking. But video-tape recording makes it possible to conjure with time in this way. Such activation of the observer could have several good effects: it compels him to pay close attention, to think more deeply and to take a more personal attitude. It can also be arranged so that misunderstandings are immediately corrected. Such tasks could therefore help to make the observation more meaningful and lessen the gap between it and what the students would do themselves in practice. "Taskinterfoliated demonstration tapes" will in this way be very similar to other self-instructional material and also to the "classroom simulators" which have sometimes been used (usually with the aid of filmed material). They could be used not only for training in adequate decisions and teacher-behavior, but also as a test of the student teacher's repertoire of behavioral tendencies relevant to the classroom role. They could also perhaps pave the way for better methods of selection and better aids to grading than those we now have.

Finally, "mirror-showing" or "self-confrontation" (Figure 8. 4, f) means that a person can study himself and his own behavior patterns by means of vide-tape recording. This method has been used for example in athletics teaching, where high-jump or stroke techniques are studied by the athletes themselves afterwards. A similar technique can be used in teacher training; to observe one's own lessons would become , with the aid of the video-tape, not something supernatural, but a highly practical aid in our attempts to make the student teacher aware of his shortcomings and merits.

So far we have mainly considered different ways of using closed-circuit television and video-tape recording in order to make students' lesson observation and teaching practice more effective. Obviously the adventages of these two aids as " observation amplifiers" can also be used in other ways in teacher training. In a situation where there is a lack of teachers of educational theory, CCTV can thus be used for "multiple direct teaching" (lectures and demonstrations are simultaneously transmitted to several different lecture rooms, perhaps even from one School of Education to branches in other places). Lectures in education and method who are going to give lectures, demonstrations etc. on public television can, with the aid of the video-tape recorder, give themselves teaching practice ("rehearsal with play-back"). The technique of judging lessons could well be practised by means of group evaluation of recorded material followed by discussions. The reliability of teaching marks could also possibly be increased by using a technique whereby a number of independent assessors judge the same lesson (which should not be administratively impossible with the help of recorded material: "objectivised behavior assessment"). There is not room here to go more deeply into the advantages and disadvantages of these different possibilities. They should however be borne in mind for further research work.

Among the often mentioned difficulties in teacher training, we may note our lack of basic knowledge as far as teaching methods are concerned, and the fact that these problems are connected with insufficient research and the earlier difficulties in recording objectively actual events in the classroom. There is no doubt that here too CCTV and video-recording have opened up new possibilities which should gradually contribute to more definite basic knowledge. The advantages of video-recording as a "data-storage research aid" should not be forgotten in this connection.

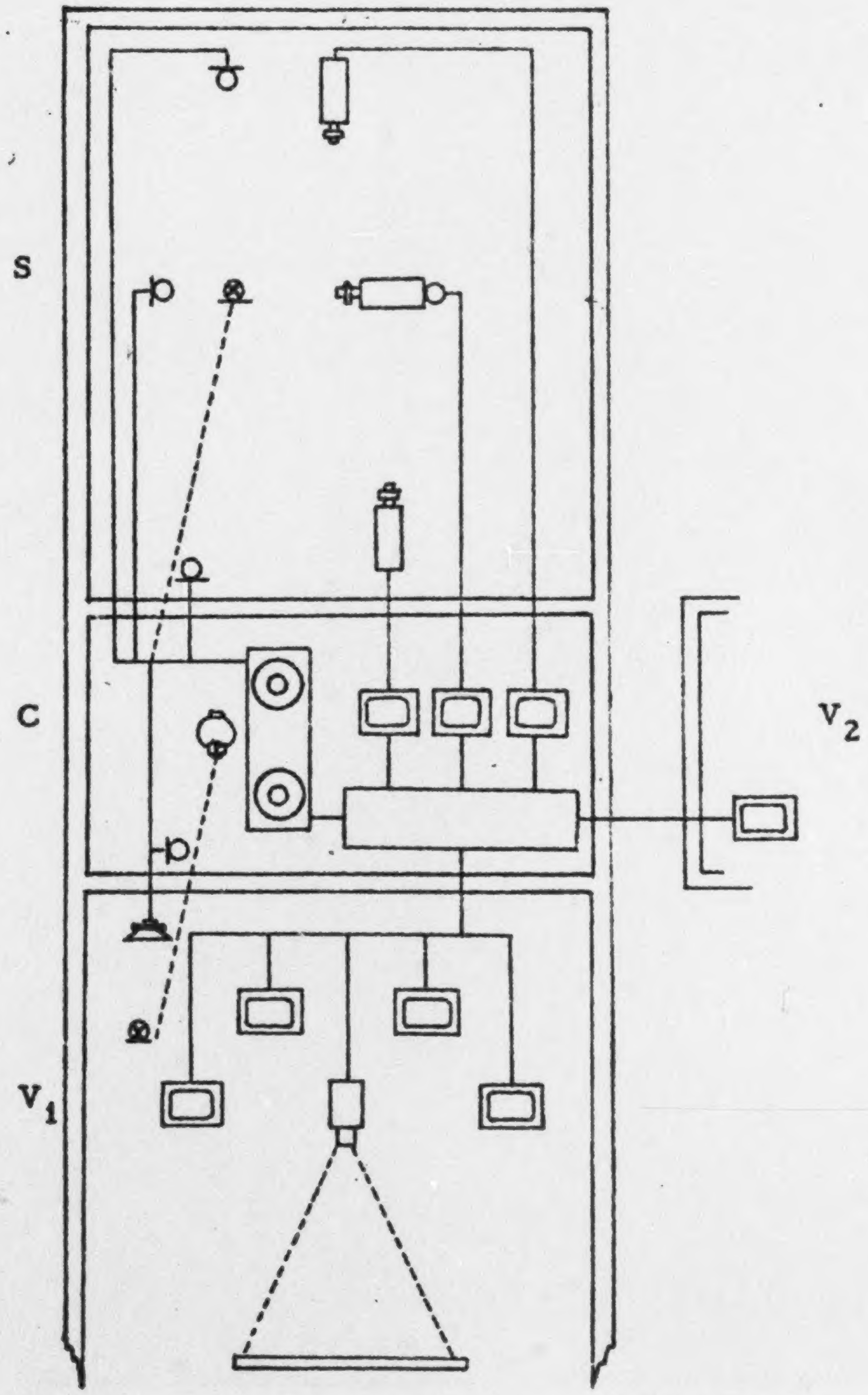
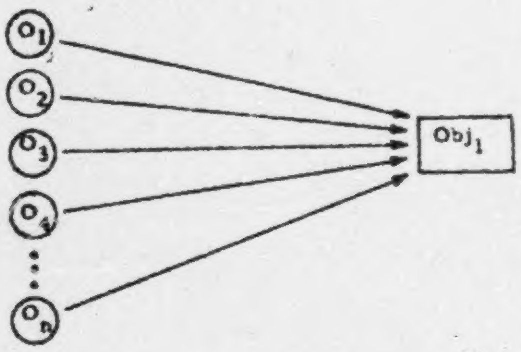


Figure 8.3 Typical installation of CCTV

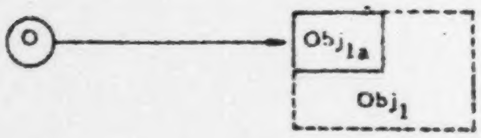
In the sending area (S) there are three TV cameras, one of which can be directed by remote control, three fixed microphones and one portable teacher's microphone.

In the control room (C) there are monitors, picture selectors and a video-tape recorder etc. In a large viewing area (V_1) there are, in addition to loudspeakers, either a number of TV receivers (four in the picture) or an enlarging projector. Viewing can take place simultaneously in separate rooms (e.g. V_2). A tutor/supervisor in the viewing room can communicate with the control room via a portable microphone.

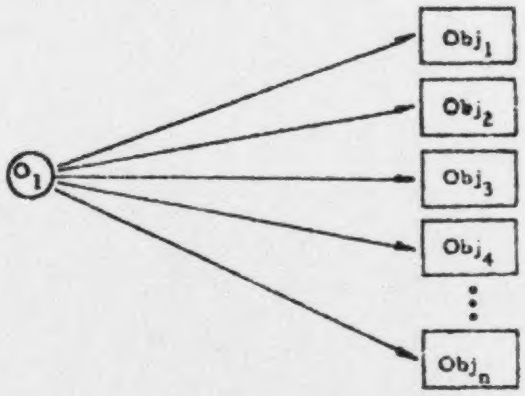
a) "Micro-showing"


O_1
O_2
O_3
O_4
O_n
Obj_1

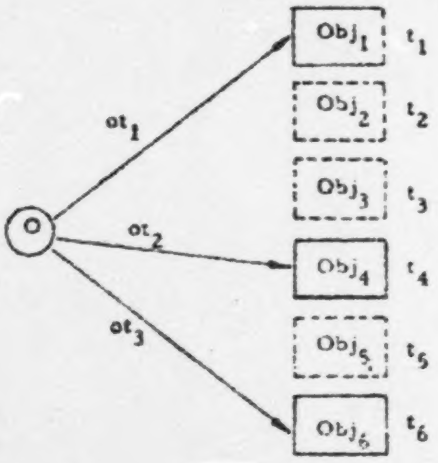
d) "Focused showing" (spatial selection)


O
Obj_{1a}
Obj_1

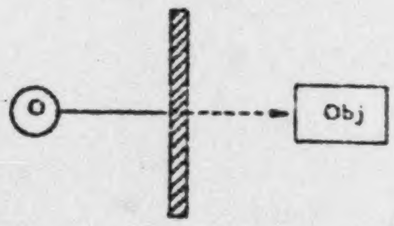
b) "Macro-showing"


O_1
Obj_1
Obj_2
Obj_3
Obj_4
Obj_n

e) "Concentrated showing" (time selection)


O
ot_1
ot_2
ot_3
Obj_1 t_1
Obj_2 t_2
Obj_3 t_3
Obj_4 t_4
Obj_5 t_5
Obj_6 t_6

c) "Shielded showing"



f) "Mirror showing"

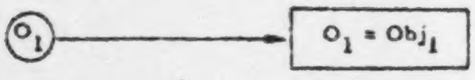


Figure 8.4 Schematic examples of different types of "observation amplifying" arrangements possible with CCTV and video-tape recording.

Symbols: 0_1, 0_2, 0_3 etc. = observers

Obj_1, Obj_2 etc = objects for observation

t_1, t_2 etc. = time 1, 2 etc. in a sequence of events

ot_1, ot_2 etc. = time 1, 2 etc. in a sequence of observations

8. 5 VARIOUS NON-MECHANICAL ARRANGEMENTS

After this excursion, dealing with an important but rather special aid in instructional system building, let us return to the question of mechanical vs. nonmechanical arrangements. Since tutomat arrangements are often comparatively expensive and since many of them, in spite of the fact that they are meant for general use, have their special limitations, it is a good idea in many instances to begin with an attempt to manage without a tutomat system. Only when experience has shown that mechanical components really are desirable, is it advisable to buy one or to have one constructed. (This general recommendation does not apply, naturally, in those cases discussed earlier, where the character of the terminal situation shows immediately that some sort of tutomat arrangement is necessary.)

It can be reported parenthetically that about two-thirds of all U. S. programs commercially avialable in the year 1965 had been produced only in a tutoprint version. The relative number of programs wich were produced both for mechanical and non-mechanical use dropped noticeably from the year 1962 to 1965 (see Table 8. 1).

Table 8. 1 Mode of presentation in U. S. programs: Three surveys

	For non-mechanical use only	For mechanical use only	For both methods
Programs, 1962	31 %	7 %	62 %
Programs, 1963	56 %	20 %	24 %
Programs, 1965	66 %	21 %	12 %

(Percentage figures are based on information in "Programmed instruction materials 1964-65, covering 102 programs in 1962, 333 programs in 1963, and 291 programs in 1964-65.)

In this respect, however, there are interesting international differences. In Britain we find a predominance of machine programs (see Table 8. 2). In 1966, more than four out of five of the American programs available in Britain were in book form, while just over one in five of the British-made programs was designed as a book.

Table 8. 2 Mode of presentation: Programs available on the British market (Total figures, 1960-66)

	British	American
Text	156 (20, 8 %)	410 (87, 4 %)
Machine	593 (79, 2 %)	59 (12, 6 %)
Total	749	469

Later on a decrease is seen in British machine program figures. Nevertheless, in the 1969 survey (Cavanagh & Jones, 1969) they still represent the majority of British programs (1079 out of 1553, or 60 %).

If we want to try out a simple tutoprint arrangement to begin with, what are the possibilities? Among the most common methods of procedure are the "panel-books" (in which the presentation units consist of shorter parts, panels, on one page and where these units are arranged in some form of succession) and "scrambled book" (in which the presentation units ordinarily consist of entire pages, and where these units are arranged in a more "scrambled" fashon). Panel-books can also appear in different forms (among others, different "reading directions"). Here are some examples of different tutoprint arrangements at the present time:

(a) Panel-book with vertical progression ("The vertical panel-book"). This arrangement differs least from an ordinary textbook. The pages are read as usual from top to bottom and in the usual order. That which in appearance distinguishes this type of book from conventional books is chiefly the more widely spaced printing. Every instructional unit is usually demarcated from the others with heavy horizontal lines. The student writes his answer as a rule within the frame of the instructional unit, often on an empty line which leaves blank one or more key words from the text. The model answer appears relatively near the response request, perhaps in a special column in the margin either right beside the response request or - in order not to be too conspicuous - beside the following unit (see Figure 8.5).

The method of procedure is quite a common one (see, for example, an early and well-known introduction to programming techniques: Markle et al., 1961). The printing and editing techniques are simple. The greatest drawback is actually that the temptation to look at the key answer immediately is so great. But with certain types of students and certain kinds of assignments, this is undoubtedly not of very great importance.

Some studies have even shown faster work with the same degree of knowledge, when the students are specifically instructed to read the answer at once (instead of first writing down their own answer and then looking at the key answer). This method can undoubtedly function well in some situations, especially when the percentage of correct answers is high in any case and the model answer is, therefore, a relatively "unnecessary" confirmation of something which the student understands immediately. This should be an interesting field for further research, since it concerns one of the fundamental principles of programmed teaching. Some of the early programmers emphasized strongly the significance of the overt answering behavior and seemed even to have difficulty in acknowledging that learning can take place without this overt reaction. On the other hand, many interpret research experience in this area to mean that increase in effectiveness in programming is more dependent on the improved focusing of the stepwise presentation and the cognitive working over of these well-focused stimuli than with the observable response behavior in itself. The latter can be of value as a guarantee for the cognitive working over, but it need not be essential to learning for that resson.

(b) Panel-book with horizontal progression ("the horizontal panel-book"). Here an attempt has been made to avoid the difficulties with the great "cheating temptation" discussed above by setting up the book horizontally. The pages appear much the same as those in the vertical panel-book with a row of clearly demarcated test items. The student does not read the book page by page, however. Instead he usually goes from the upper section of the first page to the upper section of the next page, etc. In other words, he reads a certain section of the pages throughout the whole book (or in any case through a part of the book) before he goes over to other sections of the same pages.

The simplest arrangement would be, therefore, to let the first item on the first page have its key answer in the first section on the second page, after which the new item at the top of the third page would have its key answer in the first section on the fourth page. Cheating is still easy, it is true, since it is just a matter of turning the page, but the temptation is less than when the key answer information is placed right next to the test item. In order to avoid disturbing factors from the answer to the preceding test item, it is probably better to allow the student to turn the page after every presentation unit. By this means the first test item on the first page has its key answer on the third page, after which the new test items on the fifth page have their key answers on the seventh page (compare Figure 8. 6, Type A).

One constructional disadvantage of the horizontal panel-book is that editing is more complicated (the addition of just one unit can involve rearranging large sections). One disadvantage in respect to teaching effectivity is that the pupils might possibly have difficulty in "navigating" the transition from one page to the new page and can easily land on the wrong "track". In some cases an attempt is made to prevent this by printing every other section in a contrasting style (for example, on a grey background). An economic drawback, finally, is that this method of procedure involves the consumption of a great deal of paper, since the key answer panel uses as much paper as the test item panel. In order to save paper, therefore, the second unit is often allowed to follow directly after the key answer to the first unit (within the same section and same page; compare Figure 8. 6, Type B). This has been done, for example, in one of the best-known, "classical" programmed textbooks, namely Holland & Skinner: "The Analysis of Behavior".

One difficulty with the last-mentioned method can be that focusing on the new items can be disturbed by the preceding answer. In theory it is naturally better to have response request 1 and key answer 1 within the field of vision simultaneously (as often is the case with machinepresentation), than to see key answer 1 and response request 2 at the same time (which is more often than not the result of an effort to save paper in the horizontal panel-book). The latter arrangement can be no small source of disturbance, especially when the aim is to teach a special type of response with varying stimuli and gradually fading prompting assistance in a certain task sequence. In some programs at least it would undoubtedly be a case of injudicious zeal to use this paper-saving technique.

(c) Panel-book with zigzag progression ("Zigzag Book"). One way of solving the problem - to have the response request and key answer in the same field of vision after the student answer without their also being in the same visual field before - would be to work with "cut" sections which can be turned forward and backward independently. Then, for example, item 1 can be given in the first section of the first page, and key answer 1 be given in the second section of page three. While the task of the item is being solved, the key answer is concealed. When the problem is solved, the answer is made visible (by folding down the upper flap of panel 2), but the response request is still within the visual field. (See Figure 8. 7 and Figure 8. 8.)

(d) Panel-books with extra aids. The temptation to cheat can be diminished to some extent and, in any case, focusing increases with the vertical panel-book if some type of aid is used for covering the key answers while the test items are being solved. It can be a separate cover stick or one which glides along a groove in the cover, or perhaps a separate outer cover equipped with a series of side flaps which can successively be turned up.

(e) The Scrambled Book. One of the best-known types of programmed textbooks is Crowder's so-called "scrambled book". In this version a whole page is used, as a rule, for each information unit with its response request. On one page appears first information and then a control problem. The student then must choose between a number of alternative answers, after which he is referred to one of a number of different pages, depending on which alternative he has chosen. If he has made the correct choice, the new page presents new information and the new unit. If his choice has been wrong, he finds an explanation of the mistake. In the latter case he is usually then referred back to the previous page with the recommendation that he choose a better answer alternative (see Figure 8. 9).

That arrangement is, therefore, especially adapted to individualization of content, and it also functions in discouraging the temptation to cheat. (It is possible, of course, to peek at all the pages to which reference is made before beginning to think, but for most students it is more satisfactory - and often faster - to think first and turn pages later.) One disadvantage can be, however, that in the usual format we are forced to present to the student completed answer alternatives, which under some circumstances is perhaps less desirable. Considering the terminal behavior at which we are aiming, the choice reactions may not be sufficient, and it is not always wise to present confusing misinformation in the earlier phases of the teaching process (a more detailed discussion of these problems will be presented in connection with an analysis of different "flow models").

(f) "Cheat-proof" tutoprint arrangement. None of the tutoprint systems mentioned above is cheat-proof even if the degrees of temptation and opportunity may vary. Attempts have been made to devise more cheat-proof systems. These usually have the drawback that they deal with choice reactions (multiple choice answers). If this is acceptable with reference to the terminal behavior, then one of the following arrangements may be worth trying - surface covers, perforations, embossed key answers, or chemically prepared answer sheets.

The first technique means that the student selects one of the answer alternatives by erasing an opaque cover either directly after or under the alternative in question. Under this cover he can find the information which tells him whether he has chosen correctly or not. At the same time the student has, naturally, no possibility of invalidating his selection. The second method - perforation - can take a number of forms. In principle it means that the student answers by making a hole with his pencil in the answer sheet at the alternative he considers correct. Through this hole he gets, by one means or another (e. g. with different colors), a report as to whether he has answered correctly or incorrectly. The third method - the embossed answer technique - makes use of a response unit consisting of an answer sheet printed on the outside of an envelope which contains the answer plate with raised symbols as well as carbon paper. The student answers by rubbing the blunt end of the pencil over the selected answer pane, which makes visible the information on the accuracy of the answer (Figure 8. 10). The fourth - chemical - technique involves the use of a special pencil or paintbrush with which the student either touches or dampens an answer sheet, thus indicating which choice he thinks is the right one. The answer sheet is chemically treated in such a way that it turns a certain color (e. g. blue) if the answer is correct, and another color (e. g. red) if the answer is wrong.

To sum up, among the questions which should be considered before selecting a tutoprint arrangement are the following: Is a linear or a branched unit sequence desired? Is a self-devised answer essential for the terminal behavior, or are choice reactions sufficient (or even more natural)? How much weight should be placed in our special student groups on possibilities for cheating and the temptation to cheat? How important is it to be able to have the response request and the key answer simultaneously in the visual field after the student response? How important is it in our special programs not to have distracting elements from previous items in the visual field while a new problem is being solved? If the answers to these questions are unequivocal, then the selection of an arrangement for the special purposes can be relatively simple. But it is also possible that none of the existing systems is entirely satisfactory. Efficient arrangements which work with selfcreated answers and at the same time have low risk for cheating, or none at all, do not seem to be available at the present time. Neither are a number of the compromises between good focusing and economizing on paper especially successful. In these areas new and better ideas are needed.

Type A:

Task 1	Answer 1
Task 2	Answer 2
Task 3	Answer 3
Task 4	Answer 4

Type B:

	Task 1
Answer 1	Task 2
Answer 2	Task 3
Answer 3	Task 4

Figure 8.5 "The Vertical Panel-Book"

Type A:

Page 1	Page 3	Page 5
Task 1	Answer 1	Task 2
Task 101	Answer 101	Task 102
Task 201	Answer 201	Task 202
Task 301	Answer 301	Task 302

Type B:

Page 1	Page 3	Page 5
Task 1	Answer 1 Task 2	Answer 2 Task 3
Task 101	Answer 101 Task 102	Answer 102 Task 103
Task 201	Answer 201 Task 202	Answer 202 Task 203
Task 301	Answer 301 Task 302	Answer 302 Task 303

Figure 8.6 "The Horizontal Panel-book"

Note: Even-numbered pages need not be left blank, but can as a rule be used for new tasks and answers, for example, as follows (for Type A): page 2 upper: Task 51; page 4 upper: Answer 51, etc.

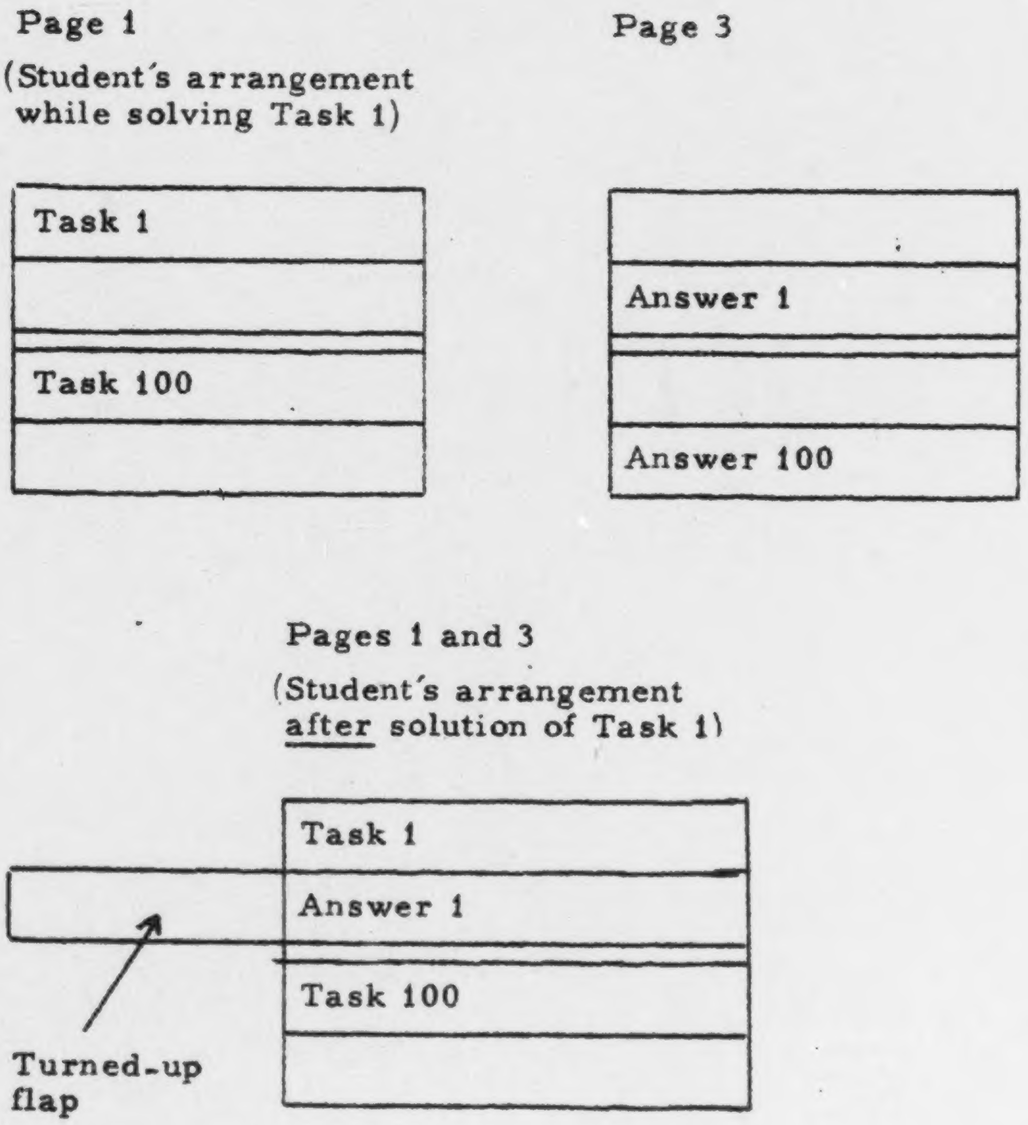

Page 1
(Student's arrangement while solving Task 1)
Task 1
Task 100
Page 3
Answer 1
Answer 100
Pages 1 and 3
(Student's arrangement after solution of Task 1)
Task 1
Answer 1
Task 100
Turned-up flap

Figure 8. 7 "Zigzag Book"

Type of arrangement	'Within the visual field'	
	At stage A (ex., solving Task 3)	At stage B (ex., answer control for Task 3)
Vertical Panel-Book	*$T_3 + K_3$*	$T_3 + K_3$
Horizontal Panel-Book, Type A	only T_3	*only K_3*
Horizontal Panel-Book, Type B	*$K_2 + T_3$*	*$K_3 + T_4$*
Zigzag Book	only T_3	$T_3 + K_3$

Figure 8. 8 Principle differences with reference to "focusing balance" between four types of tutoprint arrangements for linear program.

In the above chart the letter T is used to symbolize the given tasks (with or without student answer affixed), while the letter K represents the "key answer". The stimuli arrangements which most likely are less suitable (since they bring about inadequate focusing-balance) are in italics. The vertical panel-books provide too *little* screening in the first work stage, while the horizontal panel-book Type A provides too *strong* screening in the second stage. The horizontal panel-book Type B gives too *little* screening in the first stage (when Task 3 is solved, the answer to Task 2 may furnish an inadvertant prompt) and an *inadequate* shielding in the second stage (too great, inasmuch as Task 3 should still be accessible; too little, inasmuch as Task 4 is not relevant to observation of key to Task 3). Of the four arrangements shown here, only the "Zigzag Book" seems to fulfill the demands of focusing balance.

Page 1

This is a scrambled book.
The pages are not to be read in the usual order.
Turn to page 3 and read Task 1.

Page 2

You chose Answer 1 a
Too bad . . .
Explanation of error 1 a
Go back to page 3 and try again!

Page 3

Information 1
Task 1
Answer 1 a - See page 2
Answer 1 b - See page 5
Answer 1 c - See page 11

Page 4

You chose Answer 2 a.
Tough luck . . .
Explanation of error 2 a
Go back to page 5 and try again!

Page 5

You chose Answer 1 b.
CORRECT!
Information 2
Task 2
Answer 2 a - See page 4
Answer 2 b - See page 7
Answer 2 c - See page 13

Figure 8. 9 Scrambled Book

Answer envelope

Name: ______________

Task: ______________

Date: ______________

	a	b	c	d	e
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					

	a	b	c	d	e
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					

Figure 8. 10 Example of attempt to devise "cheat-proof" tuto-print arrangements (raised answer technique)

Each work sequence is represented by an answer envelope printed somewhat like the above, an answer plate with raised letters, numerals, etc., as well as a carbon and a copy-paper. When the answer plate plus a carbon and a copy-sheet have been placed in the envelope, the squares printed on the front of the envelope match up to the symbols on the answer plate inside. If the student now rubs a certain square with a pencil, the symbols from the answer plate are visible in that square; at the same time they are also registered on the copy paper in the envelope.

One way of using this arrangement is to work with a question list with choice of answers. The student marks on the sealed envelope the answers he thinks are correct. The symbols which then become visible let him know whether he is right or wrong. The symbols can, moreover, also provide page references (for explanations of the errors, for exemple) or can give information in the form of words or numbers. The student knows that he cannot change his answer without its showing on the enclosed copy.

NOTE ON REFERENCES

The present report is the first in a series of three (issued as "Didakometry", Nos. 30, 32 and 33). The references have all been collected in the third report. Therefore, the reader is referred to the reference list in Didakometry, No. 33.